

102487

RISK ASSESSMENT

**ALLIED-BENDIX AEROSPACE - FLIGHT SYSTEMS DIVISION
SOUTH MONTROSE, PENNSYLVANIA**

15 July 1988

Denice Y. Heller
Denice Y. Heller
Project Manager

Marilyn A. Hewitt
Marilyn A. Hewitt, P.G.
Project Director

Prepared for:

Bendix Aerospace Flight Systems Division

Prepared by:

**Environmental Resources Management, Inc.
855 Springdale Drive
Exton, PA 19341**

AR301080



TABLE OF CONTENTS

	<u>Page</u>
Section 1 - Introduction	1-1
1.1 Background	1-1
1.2 Risk Assessment at Hazardous Waste Sites	1-1
1.3 Site Description and History	1-3
1.4 Risk Assessment Data Base	1-4
Section 2 - Indicator Compounds	2-1
2.1 Regional Aquifer	2-4
2.2 Soils	2-8
2.3 Surface Waters	2-9
2.4 Summary	2-10
Section 3 - Toxicity Evaluation	3-1
3.1 Trichloroethylene	3-3
3.2 trans-1,2-Dichloroethylene	3-4
3.3 Vinyl chloride	3-4
3.4 Benzene	3-5
Section 4 - Exposure Evaluation	4-1
4.1 Source of Contamination	4-2
4.2 Environmental Fate and Transport	4-2
4.2.1 Fate of Indicator Chemicals	4-3
4.2.2 Transport of Indicator Chemicals	4-3
4.2.2.1 Regional Aquifer	4-3
4.2.2.2 Soil	4-5
4.2.2.3 Surface Water	4-5
4.2.2.4 Air	4-6
4.3 Exposure Analysis	4-7
4.3.1 Identification of Points of Exposure	4-7
4.3.2 Populations Potentially Exposed	4-7
4.3.2.1 Regional Aquifer	4-8
4.3.2.2 Soils	4-8
4.3.2.3 Surface Waters	4-9

TABLE OF CONTENTS (continued)

	<u>Page</u>
4.3.3 Exposure Point Concentrations	4-9
4.3.3.1 Regional Aquifer	4-10
4.3.3.2 Soils	4-13
4.3.3.3 Surface Waters	4-14
4.4.1 Methodology	4-15
4.4.1.1 Inhalation Exposures	4-18
4.4.1.2 Dermal Exposure	4-19
4.4.1.3 Ingestion Exposure (Water)	4-20
4.4.2 Exposure and Daily Intake Calculations	4-21
4.4 Maximum Extent of Potential Exposure	4-15
Section 5 - Risk Characterization	5-1
5.1 Applicable and Relevant Standards	5-1
5.2 Noncarcinogenic Risk	5-3
5.3 Carcinogenic Risk	5-4
5.4 Uncertainty	5-6
Section 6 - Conclusions	6-1
6.1 Background	6-1
6.2 Methodology	6-1
6.3 Conclusions and Summary	6-1
Acronyms	
References	
Appendix A	Sampling Data Used in Preparation of the Bendix Aerospace South Montrose, Pennsylvania Endangerment Assessment
Appendix B	Worksheets Used in Preparation of the Bendix Aerospace South Montrose, Pennsylvania Endangerment Assessment
Appendix C	EPA Modification to the IARC Approach
Appendix D	Toxicology Profiles of the Indicator Compounds for the Bendix Aerospace Endangerment Assessment
Appendix E	Environmental Fate and Transport of the Indicator Compounds for the Bendix Aerospace Endangerment Assessment

SECTION 1

INTRODUCTION

The need to include estimates of risk in the decision-making process for contaminated sites has been recognized by the US EPA, and is now a required part of CERCLA site investigations. Risk Assessment (RA) is a process which evaluates the collective demographic, geographic, physical, chemical, and biological factors at a site to determine whether or not there is risk to public health or welfare or the environment.

1.1 Background

This report was prepared to evaluate the level of potential risk under existing conditions at the Bendix Aerospace flight Systems Division facility, South Montrose, Pennsylvania. Initial Remedial Investigations and Feasibility Studies were conducted in 1984. After those reports were submitted to EPA, the Agency requested that a Risk Assessment be conducted to comply with current requirements under the Superfund program.

1.2 Risk Assessment at Hazardous Waste Sites

EPA has proposed guidelines for the preparation of Risk Assessments at hazardous waste sites. These guidelines include the Draft Endangerment Assessment Handbook (6), Superfund Public

Health Manual (7), Draft Superfund Exposure Assessment Manual (8), and Toxicology Handbook (9).

The process involves the evaluation of exposures to "indicator chemicals" in terms of health risk and compliance with environmental standards. In the process, the no action alternative is evaluated first, and if the level of its risk is unacceptable, then remedial alternatives are considered. Both carcinogenic and non-carcinogenic risks are considered, although levels for the protection of human cancer are normally so restrictive that the selected remedies are usually targeted to protect against cancerous rather than non-cancerous effects. For ground water remedial actions, at least one alternative is developed which would attain applicable or relevant and appropriate requirements (ARARs) for carcinogens where they are available or a 10^{-6} risk level for carcinogens without standards for current and potential exposure. This alternative should be used as a point of departure in analyzing a range of alternatives.

There is a great deal of conservatism in the process that EPA uses to describe human cancer risks. EPA considers animal test evidence quite liberally in determining the strength of evidence that a substance is a human carcinogen, and in this process includes false positives in its estimations. Additionally, the EPA has proposed to use the linear multistage dose-response model to predict human cancer risk at low doses. This model is more conservative in calculating intakes over a lifetime, for instance in determining the amount of air that is breathed or water consumed. It also assumes that the inhaled or ingested

substances are completely absorbed through the lung and gastrointestinal tract, respectively, although it is known that only a fraction of the mass behaves in this way. These combined factors lead to a very high level of conservatism in the overall process with the effect of over-estimating risks. The scenarios developed as part of this assessment for the Bendix-Allied site follow this philosophy as well, leading to an overall over-estimation of risk.

1.3 Site Description and History

Allied-Bendix Aerospace (formerly the Bendix Corporation) Flight Systems Division plant site is located in Bridgewater Township, Susquehanna County, adjacent to the Village of South Montrose, Pennsylvania. The site has been used to manufacture aerospace components. In 1982 and 1983, Chester Engineers conducted Phase I and Phase II hydrogeological investigations which provided data partially defining the extent of ground water contamination at the plant facilities. The Phase I assessment defined the shallow subsurface geologic and hydrologic conditions and reviewed the initial data on the extent of contamination in a former disposal area. The Phase II investigation provided data on the shallow glacial till system in the potential contaminant source areas, at the western property boundary and in the southeastern section of the plant property. Examination of the ground water data indicated that chlorinated organic solvents were present in the glacial till ground water flow system at the site. Subsequent investigations by ERM in 1984, 1985, 1987 and 1988 have defined in detail the extent and dynamics of contaminant migration at the site.

1.4 Risk Assessment Data Base

In order to complete a comprehensive RA, two data bases must be developed. One data base must include information on the dynamics of the site and the potential migration pathways of site-related chemicals. The other data base must include information on the chemicals in various site media. The first class of data, including a description of the site's geology and hydrogeology, is contained in three ERM reports, "Hydrogeologic and Soils Investigation Report," January 1985, "Bendix Aerospace Flight Systems Pump Test and Ground Water Flow Conditions," March 1988, and "Supplemental Remedial Investigations at the Bendix Aerospace Flight Systems Division," July 1988.

The chemical data base consists of data collected for ground water on site in both the shallow glacial till aquifer and the deep bedrock aquifer, off-site residential wells, surface water, soils, and air quality. Chemical data is also contained in the first and third of the above-mentioned reports. In addition, quarterly ground water and surface water monitoring data have been collected since 1984, and have been included in the chemical data base for this RA. Appendix A presents summary tables of the chemical data base used in this RA by media.

SECTION 2

INDICATOR COMPOUNDS

For the purposes of risk assessment, "indicator chemicals" are selected on a site-specific basis. These are generally the compounds at the site that have the following characteristics:

- they are highly toxic, persistent, and mobile;
- they are the most prevalent compounds at the site; and
- they provide a representative analysis of the major potential risks.

The selection and ranking of the indicator chemicals for the Bendix Aerospace site follows the procedure outlined in the Superfund Public Health Evaluation Manual (7). All worksheets used in the selection of the indicator chemicals are provided in Appendix B. Using the chemical list obtained from the site data, toxicological information about each chemical was compiled using Appendix C of the Superfund Public Health Evaluation Manual (7). This information includes toxicologic class [potential carcinogens (PC) or noncarcinogens (NC)]; the severity ratings value for noncarcinogens; the weight-of-evidence ratings for carcinogens; and toxicity constants for the various environmental media. The chemicals identified at the site were subdivided into potential carcinogens and noncarcinogens. An indicator score (IS), the chemical concentration multiplied by the toxicity

constant (CT), was calculated for each medium and then summed for the aquatic and terrestrial media separately to yield a total indicator score for each chemical. The chemicals were then ranked numerically by decreasing indicator scores. The top-scoring compounds (based on IS values) were then re-evaluated using frequency of detection, water solubility, vapor pressure, Henry's law constant, and K_{OC} to determine the final indicator chemicals. This re-evaluation has a direct relationship to the IS value but selectively eliminates those compounds which are degradation products, have similar physical/chemical properties, or have comparable half-lives in the various environmental media. The remaining compounds, generally those with the higher IS values, are the final indicator chemicals.

Several assumptions made during review of the chemical data for the site include the following:

- 1) Benzene, toluene, and ethylbenzene present in residential wells have been traced to a documented gasoline station leak. Therefore, these compounds are considered only if they are present in soil samples on the Bendix Aerospace property and not if they are present in the off-site ground water.
- 2) All data below the detection limits are considered zero.

Organics other than the major volatile organics detected during the ERM site investigation (10) were summed and presented as "other VOC." These other VOC compounds were reviewed and found present in minor quantities, and their total was generally less

than 20 ppb. These other VOC compounds are of the same class as the more prevalent compounds, and may be due to degradation of these compounds, or the presence of slight impurities in the industrial grade solvents used. Based upon this review and the minor quantities detected, these other VOC compounds were not considered further during the indicator chemical selection.

Data used in the selection of indicator chemicals have been subjected to comprehensive quality assurance and quality control review, and EPA-approved contract laboratories were utilized for sample analysis. ERM's quality control and quality assurance procedures were implemented, including chain-of-custody documentation, split samples, replicate analyses, sample spiking with an internal standard, routine instrument calibration, methodology (extraction) blanks, adherence to recommended sample holding times and storage temperatures, etc.

A minimum, maximum, and average concentration for each chemical was calculated for each appropriate aquatic and terrestrial medium (Worksheets 1 and 6). Toxicological information consisting of PC and/or NC classification; an EPA category ranking for oral and inhalation routes; and toxicity constants for water, soil, and air, respectively, were compiled from Appendices C-3 through C-6 of the Superfund Public Health Evaluation Manual (7). These are found in Worksheets 2 and 7. The toxicity constants for each medium were multiplied by the respective maximum and representative concentrations from Worksheet 1 to yield CT scores which were summed for each compound to give an IS value. Based upon the IS, the compounds were tentatively ranked in descending order. This procedure was

used to determine a tentative toxicity ranking for the carcinogens (Worksheets 3 and 8) and the noncarcinogens (Worksheets 4 and 9). The final IS values and ranking for carcinogens and noncarcinogens are compiled in Worksheets 5 and 10.

The investigation at the site (10) revealed that the contaminants present in the soils, regional aquifer, and surface water varied. Therefore, each medium was considered separately in the risk assessment process. Separate indicator chemicals were thus developed for the regional aquifer, surface water and the on-site soils because they have been shown to be distinctly different environments.

2.1 Regional Aquifer

The regional aquifer at the Bendix Aerospace Montrose plant consists of a deep bedrock aquifer overlain by dense glacial till. The till at this site cannot produce water sufficient for drinking purposes and thus is not a potable aquifer. Therefore, the data included in this process are from the bedrock aquifer, and include the Bendix production wells, residential wells, and on-site monitoring wells-MW-6, 84-9, 84-10, 84-11, 84-12, AW-1, PW-2, PW-3, PW-4 (refer to ERM, Inc., (10) for data on individual sampling sites, dates, and maps). The wells used for residential water exposure were samples taken at the taps of 44 residences. All sampling data used for determination of media concentrations are presented in Appendix E. Several chlorinated aliphatic hydrocarbons were detected in the ground water, surface water, or Montrose residential water supply and consisted of methylene

chloride, trans-1,2-dichloroethylene, 1,1-dichloroethane, chloroform, and trichloroethylene.

The results of the Supplemental Remedial Investigation serve to verify the historical site data regarding the occurrence and concentrations of the various volatile organic compounds present at the site. However, at Well B-1 in the Old Landfill area, the supplemental RI data indicate that concentrations of vinyl chloride may be increasing. This is potentially significant to the selection of indicator compounds for the regional aquifer, as an increase in vinyl chloride concentration in the shallow overburden flow zone could in the long term result in migration of vinyl chloride to the bedrock aquifer. Thus, vinyl chloride should be evaluated as a potential indicator compound in the regional aquifer.

The occurrence of vinyl chloride at the site has been very limited in the historical data base. It has been present in most of the samples from Well B-1, in concentrations ranging from less than 100 parts per billion to the 1200 parts per billion reported in the Supplemental RI. It has also been detected downgradient of the Old Landfill at Well B-11 at a few tens of ppb, and at top-of-bedrock Well 84-4 (adjacent to B-1) at concentrations of less than 10 ppb. There has been no regularly occurring detection of vinyl chloride in other sections of the site. Only spot low level concentrations have been reported downgradient of the TCE tank area.

The preferential occurrence of vinyl chloride at the Old Landfill is consistent with its method of generation. Vinyl chloride is

produced by the microbiological degradation of trichloroethene to cis and trans-1,2-dichloroethene, and the subsequent breakdown of those compounds to vinyl chloride. This process requires the presence of methanogenic (methane-producing) or methanotropic (methane-using) bacteria. This requires the presence of the food source for these two types of bacteria, which require the presence of anaerobic conditions in the subsurface. The breakdown of chlorinated ethenes to vinyl chloride is most often seen in areas where solvents were co-disposed with refuse. In the Old Landfill area, refuse was apparently disposed, and possibly burned. Thus, the Old Landfill area provides the anaerobic substrate necessary to support the biodegradation process which forms vinyl chloride.

In the Old Landfill area, the degradation process appears to be continuing to occur. Currently, all of the trichloroethene has been degraded to dichloroethene. The data indicate that during 1986 the percentage of vinyl chloride to total chlorinated ethenes increased from 3.8 percent to 13 percent. For comparison, at Well B-5 in the Pit/Trench Area, approximately 70 percent of the chlorinated ethenes are represented by trichloroethene, and no vinyl chloride has been produced. In the TCE Tank Area, no degradation of trichloroethene has occurred. Downgradient of that area, 97.5 percent of the chlorinated ethenes are represented by trichloroethene, and only spot, very low concentrations of vinyl chloride have ever been detected. Finally, in the former Solvent Evaporation Area, the trichloroethene is approximately 94 percent degraded to dichloroethene. However, no vinyl chloride has been produced. The degradation which has occurred is likely due to the limited

presence of wood and other biodegradable materials present in the subsurface fill beneath the area.

The potential impact of the current concentrations of vinyl chloride on the regional aquifer can be estimated using the observed dilution factors for total VOCs between the shallow flow component at Well B-1 and the bedrock flow component at Well 84-11. Historically, this dilution factor has averaged 0.0056. Applying this dilution factor to the 1200 ppb vinyl chloride reported in the Supplemental RI, the potential concentration in the bedrock aquifer used to evaluate vinyl chloride as a potential indicator compound is 7 ppb.

The Supplemental RI data indicated that with one exception, no non-volatile compounds are present in the ground water at the site. That exception was the detection of 13.1 ppb of PCBs in Well B-5 in the former Pit Area. Applying the dilution factor between Well B-5 and bedrock Well 84-11, the potential PCB concentration in the Bedrock aquifer is 0.002 ppb. This concentration is used to evaluate PCBs as a potential indicator compound in the regional aquifer.

A site-specific assessment of the water media was conducted using the proposed EPA procedures (Appendix A: Worksheets 1-5). Trichloroethylene and trans-1,2-dichloroethylene ranked high and were the most prevalent Bendix site-related organic compounds, in the ground and surface waters, and were selected as indicators. Vinyl chloride and PCBs were considered as discussed above, and vinyl chloride was also chosen as an indicator for the regional aquifer because of its high ranking. The resultant indicator

chemicals for the regional aquifer are therefore trichloroethylene, trans-1,2-dichloroethylene and vinyl chloride. Table 2-1 presents the justification of selection of indicator compounds for aquatic media at the Bendix South Montrose site.

2.2 Soils

On-site soil samples were analyzed from the TCE tank area, a former drum storage area, the hazardous waste storage pad (former drum storage area), the old solvent distillation area, the old landfill area, and old pit/trench area. All sampling data used for determination of soil and sediment concentrations are presented in Appendix A.

The results of the Supplemental Remedial Investigation serve to confirm the presence of VOCs in soils on site. In addition, the soil analyses indicate that a variety of very low concentration polycyclic aromatic hydrocarbons (PAHs) are present in the old solvent distillation area, the old landfill area, and the old pit/trench area. The occurrence of these compounds is not considered to be related to past disposal practices since PAHs are related to combustion of fossil fuels and are present in paving materials; however, the presence of PAHs on site is possibly related to past fires, "trash" burning, or use of PAH contaminated fill materials.

The site-specific selection of the soil indicator chemicals followed the procedures outlined in Section 2.1. The worksheets for the subsurface soils and sediments are given in Appendix B (Worksheets 6-10). The final indicator chemicals for the soils

at the Bendix Aerospace South Montrose site are trichloroethylene (TCE) and benzene. TCE was selected to represent the aliphatic hydrocarbons since it was present in the highest soil concentration. Benzene also represented the highest soil concentration of the aromatic hydrocarbons. Table 2-2 presents the justification of selection of indicator compounds for soil media at the Bendix South Montrose Site. Even though benzo(a)anthracene (B(a)A) and benzo(a) pyrene (B(a)P) rank high, volatilization with subsequent inhalation is the only potential exposure pathway for compounds in subsurface soils. However, since B(a)A and B(a)P were very infrequently detected and are not very volatile, they were not chosen as indicator compounds.

2.3 Surface Waters

Samples collected at Ponds 1 and 2, at the west parking lot discharge, and at three locations in the stream represent surface water at the site. Contaminants detected in the surface water consists of benzene, toluene, ethylbenzene, trichloroethylene, 1,1-dichloroethane, 1,1,1-trichloroethane, and trans-1,2-dichloroethylene. The site-specific selection of surface water indicator chemicals was included with the regional aquifer procedure described in Section 2.1. The worksheets including surface water are given in Appendix B (Worksheets 1-5). Trichloroethylene and trans-1,2-dichloroethylene were selected as indicator chemicals for the surface waters. All analysis results used for determination of surface water concentrations are presented in Appendix B.

As requested by the EPA and PADER, the Supplemental Remedial Investigation included analysis of a sediment sample from the wetland below the effluent discharge from Pond 2. The results of this analysis indicated the presence of some heavy metals elevated above background concentrations. This phenomenon is related to the Pond 2 discharge, which is under NPDES permit by the PADER. The metals accumulation in the soils below the discharge point is related to chemicals used for algae control in Pond 2 and to in-plant processes. The occurrence of these metals is not related to past disposal practices, but rather to current plant practices, and as such is being regulated under the NPDES permit program. Therefore, it is not addressed in this risk assessment.

2.4 Summary

The list of indicator chemicals for each medium associated with the site is as follows:

- Regional Aquifer
 - trichloroethylene
 - trans-1,2-dichloroethylene
 - vinyl chloride

- Soils
 - trichloroethylene
 - benzene

- Surface Waters
 - trichloroethylene
 - trans-1,2-dichloroethylene

The justification for selection of indicator compounds in aquatic media is presented in Table 2-1. The justification for selection of indicator compounds in soils is presented in Table 2-2.

TABLE 2-1
JUSTIFICATION FOR SELECTION OF INDICATOR COMPOUNDS
IN AQUATIC MEDIA AT SOUTH MONTROSE, PA.

Compound *	Justification	Selected
Benzene	<ul style="list-style-type: none"> - exceeded MCL in residential wells - ranked low in scoring - infrequently detected 	Nb
Toluene	<ul style="list-style-type: none"> - no exceedence of MCLs 	Nb
Ethylbenzene	<ul style="list-style-type: none"> - no exceedence of MCLs 	Nb
Methylene Chloride	<ul style="list-style-type: none"> - no available MCL - infrequently detected 	Nb
Carbon Tetrachloride	<ul style="list-style-type: none"> - exceeded MCL in ground water - scored as #1 carcinogen - detected only 5/407 	Nb
1,1-Dichloroethane	<ul style="list-style-type: none"> - no MCL available - infrequently detected 	Nb
1,1,1-Trichloroethane	<ul style="list-style-type: none"> - no exceedence of MCLs 	Nb
trans-1,2-Dichloroethane	<ul style="list-style-type: none"> - no exceedence of MCLs - ranked highly - #2 frequency detected in surface water 	Yes
Chloroform	<ul style="list-style-type: none"> - no exceedence of MCLs - infrequently detected 	Nb
Trichloroethene	<ul style="list-style-type: none"> - exceeded MCL for ground water/residential wells - most frequently detected 	Yes
Tetrachloroethene	<ul style="list-style-type: none"> - no available MCL - low ranking - infrequently detected 	Nb
1,2-Dichloroethane	<ul style="list-style-type: none"> - no exceedence of MCLs 	Nb
Chlorobenzene	<ul style="list-style-type: none"> - no exceedence of MCLs 	Nb
Vinyl Chloride	<ul style="list-style-type: none"> - potential concentration exceeds MCL - ranked highly 	Yes
PCBs	<ul style="list-style-type: none"> - infrequently detected - low ranking 	Nb

* all surface water standards met

AR301098

TABLE 2-2
JUSTIFICATION FOR SELECTION OF INDICATOR COMPOUNDS
IN TERRESTRIAL MEDIA AT SOUTH MONTROSE, PA.

Compound	Justification	Selected
Benzene	<ul style="list-style-type: none"> - known human carcinogen - ranked high to median in scoring - frequently detected 	Yes
Toluene	<ul style="list-style-type: none"> - ranked low in scoring 	No
Ethylbenzene	<ul style="list-style-type: none"> - ranked last in scoring 	No
trans-1,2-Dichloroethene	<ul style="list-style-type: none"> - ranked median in scoring 	No
Trichloroethene	<ul style="list-style-type: none"> - most frequently detected - ranked high in scoring 	Yes
Tetrachloroethene	<ul style="list-style-type: none"> - ranked high to median in scoring - frequently detected - suspected human carcinogen 	No
Benzo(a)anthracene	<ul style="list-style-type: none"> - ranked median in scoring - infrequently detected 	No
Benzo(a)anthracene	<ul style="list-style-type: none"> - ranked high - infrequently detected 	No

AR301099

SECTION 3

TOXICITY EVALUATION

The toxicity evaluation of the indicator compounds selected for the Bendix Aerospace South Montrose site is conducted to identify applicable and relevant standards and to develop a data base against which exposure point intakes can be compared in the risk characterization of the site. This evaluation includes the consideration of pharmacokinetics, applicable and relevant standards for humans, experimental studies using animals and aquatic species (where applicable), and weight-of-evidence discussions. This section presents summaries of health effects information available for the indicator compounds and a discussion of carcinogen classification systems.

A discussion of U.S. and international procedures for classifying compounds as both animal and human carcinogens, and the attendant uncertainties, are presented. Evidence of possible carcinogenicity in humans comes primarily from two sources: long-term animal tests and epidemiological investigations. Results from these studies are supplemented with information from short-term tests, pharmacokinetic studies, comparative metabolism studies, structure-activity relationships, and other relevant toxicological studies. There are three major steps in determining the weight-of-evidence for carcinogenicity:

1. characterization of the evidence from human studies and from animal studies individually,
2. combination of the two types of data into a final indication of overall weight-of-evidence for human carcinogenicity, and
3. evaluation of all supportive information to determine if the overall weight-of-evidence should be modified.

EPA modeled its carcinogen classification system after that developed by International Agency for Research on Cancer (IARC). Evidence that an agent produces cancer in humans is divided into three categories: sufficient, limited, and inadequate. Additional criteria of no evidence and no data available were added by EPA in 1986 (Federal Register, 1986). The EPA classification system for carcinogenic potential of a chemical includes Group A - carcinogenic to humans; Group B - "probably" carcinogenic to humans; Group C - "possibly" carcinogenic to humans; Group D - not classified as to human carcinogenicity; and Group E - no evidence of carcinogenicity in humans. EPA Carcinogen Assessment Group (CAG) has evaluated more than fifty chemicals as suspected human carcinogens and developed relative carcinogenic potency factors for each chemical. The ranking of potency indices is subjected to the uncertainty of comparing different routes of exposure and a number of different species. These indices are based on estimates of low dose risk using linear multistage extrapolation from the observed range. Thus, these indices are not valid when compared to potencies in the experimental or observational range, especially if linearity does

not exist in this range. Details concerning EPA modifications of the IARC approach and use of this data in the risk assessment process are presented in Appendix C.

Trichloroethylene, the common indicator compound for soils, ground water, and surface water, is classified as a "probable" human carcinogen by EPA (16). However, IARC considers that there are insufficient data to determine whether trichloroethylene is a "probable" or a "possible" human carcinogen. Vinyl chloride, one of the ground water indicator compounds, is classified as a "known" human carcinogen by both EPA and IARC. Benzene, one of the soil indicator compounds, is classified as a "known" human carcinogen by both EPA and IARC (17). trans-1,2-Dichloroethylene is classified as a noncarcinogen by EPA.

The toxicity information presented herein relies primarily on the Health Effects Assessment and/or Exposure and Risk Assessment Document for each chemical. A detailed toxicology profile for each indicator compound is presented in Appendix D; however, the major health effects resulting from exposure to each indicator compound will be discussed below. The concentrations at which acute or toxic effects occur are generally orders of magnitude higher than environmental concentrations of those compounds detected at hazardous waste sites.

3.1 Trichloroethylene

Trichloroethylene is an indicator compound for all media related to the Bendix facility. As stated above, trichloroethylene is classified as a "probable" human carcinogen. It has a low acute

toxicity with an acute oral LD₅₀ value in several species ranging from 6,000 to 7,000 mg/kg. In humans, this volatile chemical was once used for its anesthetic and analgesic properties and exposure to high concentrations is known to occasionally elicit cardiac arrhythmias. Chronic exposures have been reported to induce neurotoxic (toxic to nerves or the nervous system) symptoms such as involuntary muscular movement, sleep disturbances and psychotic episodes.

3.2 trans-1,2-Dichloroethylene

trans-1,2-Dichloroethylene is an indicator compound for the regional aquifer and for surface water. It is considered to be a noncarcinogen by EPA and IARC; however, trans-1,2-dichloroethylene has not been well studied in animals or humans. Exposure to high vapor concentrations of trans-1,2-dichloroethylene causes nausea, vomiting, weakness, tremor, and cramps in humans. Exposure to vapors can also have anesthetic and narcotic effects. Chronic exposures to low levels of trans-1,2-dichloroethylene in animals resulted in no observable changes in pathology. The oral LD₅₀ in the rat was reported to be 1,300 mg/kg.

3.3 Vinyl Chloride

Vinyl chloride is an indicator compound for the regional aquifer. It has been classified as a "known" human carcinogen, and causes blood tumors of the liver and tumors of the brain, lung, and blood and lymph system in animals. Acute exposure to high concentrations can cause narcosis, respiratory tract irritation,

bronchitis, memory disturbances, and depression of the nervous system. Chronic exposure to vinyl chloride has been associated with multiple systemic disorders involving deposition of fibrous connective tissue in the skin, acro-osteolysis, Raynaud's phenomenon, and liver and kidney damage.

3.4 Benzene

Benzene is an indicator compound for on-site soils at the Bendix facility. Benzene is a recognized human carcinogen. Epidemiological studies indicate that there is a relationship between benzene exposure and leukemia in humans. Exposure to very high concentrations in the air (about 66,000 mg/m³) can be fatal. Acute exposure can cause central nervous system depression and convulsions. Milder exposures can produce vertigo, drowsiness, headache, and nausea. Chronic skin exposure to benzene may produce blistering, erythema, and dry, scaly dermatitis.

SECTION 4

EXPOSURE EVALUATION

Potential and actual exposures to each of the selected indicator chemicals have been evaluated by first considering exposure pathways. Four elements are necessary for the construction of an exposure pathway:

- 1) a source and mechanism of chemical release to the environment;
- 2) an environmental transport medium such as air, ground water, or surface water;
- 3) a point of potential contact with the contaminated medium, or point of exposure; and
- 4) a mechanism of exposure at the contact point, such as ingestion of drinking water.

In this section, pathways have been identified for the existing site conditions.

4.1 Source of Contamination

The primary source of contamination at the site is subsurface soils. The following lists the source areas of contamination:

- the area of the TCE storage tank,
- the formerly used pit/trench area,
- the old landfill area,
- the area of a former solvent evaporation facility, and
- a former drum storage area directly behind the plant building.

4.2 Environmental Fate and Transport

Environmental fate and transport analyses are used to determine the potential for off-site migration of contaminants from identified on-site sources. The general fate and transport pathways of chemicals in the terrestrial, atmospheric, and aquatic environments are diagrammed in Figures 4-1 and 4-2. Examples of the environmental fates of the indicator chemicals include sorption onto soils and sediments, volatilization into the atmosphere, biodegradation, photochemical degradation, and bioaccumulation.

Table 4-1 summarizes the physical and chemical properties of the indicator chemicals as defined for the Bendix Aerospace site.

Figure 4-1
Fate and Transport Processes of Chemicals in the
Terrestrial and Atmospheric Environment

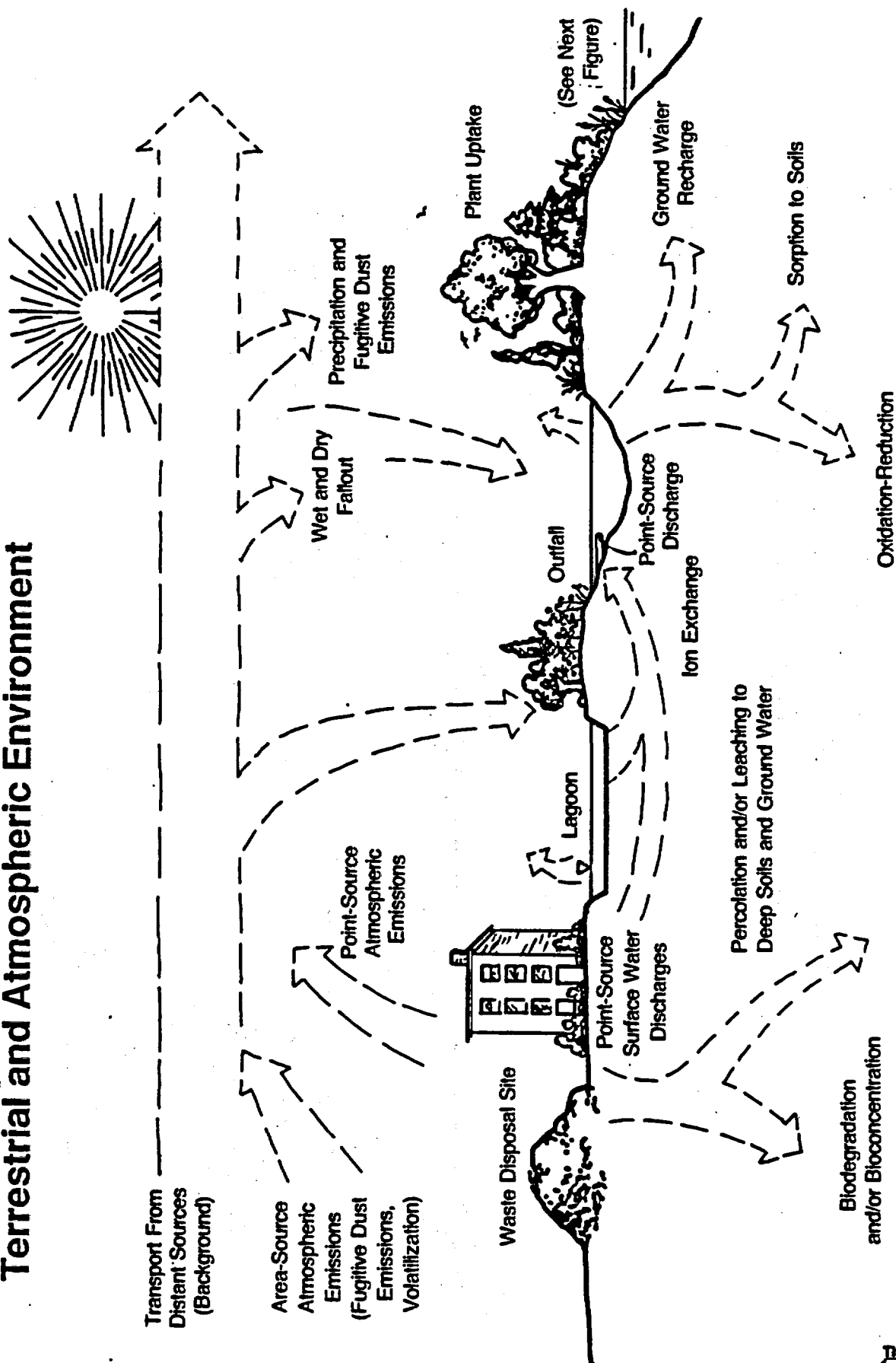
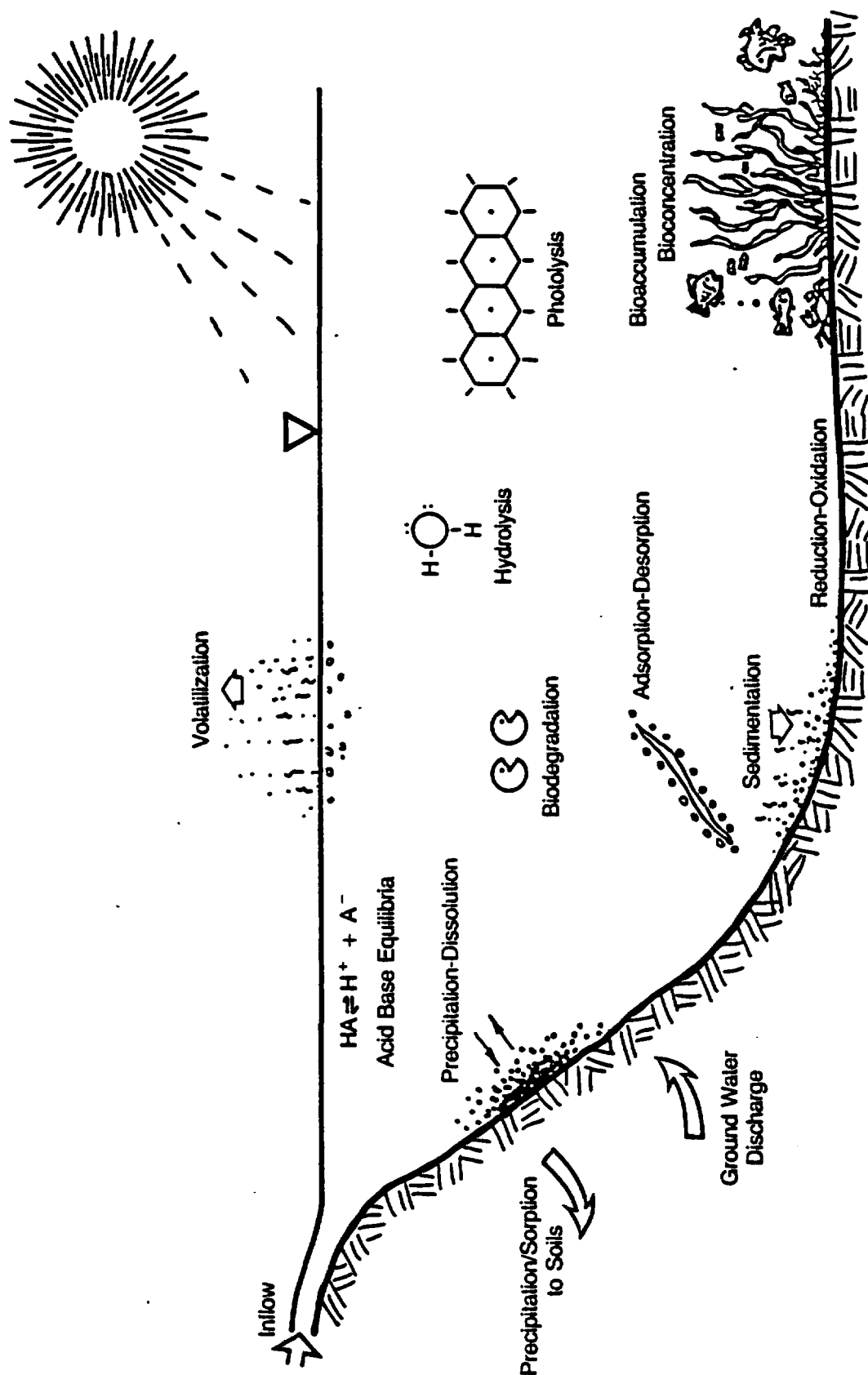


Figure 4-2
Fate and Transport Processes of
Chemicals in the Aquatic Environment



Source: ERM 1986

TABLE 4-1
PHYSICAL AND CHEMICAL PROPERTIES OF
THE INDICATOR CHEMICALS (7,11,12,13)

	Trichloroethylene	trans-1,2-Dichloro- ethylene	Vinyl Chloride	Benzene
Molecular Weight, g	131.39	96.94	63	78.12
Melting Point, °C	-73	-50	-153.8	5.5
Boiling Point, °C	87	47.5	-13.37	80.1
Density, g/mL	1.4642	1.27	0.912	0.8786
Partition Coefficients				
Water Solubility, ppm	1100 (20°C)	600 (20°C)	2670	1780 (25°C)
Octanol Water, Kow	263	123	24	135
Sediment-Water, Koc	126	59	57	135
Microorganism-Water, KB [(µg/g)(mg/L)-1]	97	48	5.7	37
Volatilization Coefficients				
Henry's Law Constant [atm m3 mole-1]	0.0091	0.067	0.0819	0.0055
Vapor Pressure, torr	57.9 (20°C)	326 (20°C)	2660 (25°C)	95.2 (25°C)
Reaeration Rate Ratio, kcv/kov	0.548	0.601	0.68	0.574

The processes influencing the fate of the indicator chemicals are evaluated in Table 4-2.

4.2.1 Fate of Indicator Chemicals

Volatilization is the primary fate process for all indicator chemicals. At the site, volatilization could occur from surface waters and/or exposed soils releasing the volatile organics to the atmosphere. None of the other fate processes are significant pathways for these compounds. A more detailed analysis of pathways for indicators is given in Appendix E.

4.2.2 Transport of Indicator Chemicals

4.2.2.1 Regional Aquifer

Ground water contaminant movement through advection and dispersion is the principal pathway of migration at the site. Hydrolysis, sorption, oxidation, and biodegradation are not considered to be significant fate processes for the contaminants of concern, indicating that the ground water pathway offers little retardation of contaminant movement.

The hydrogeologic investigation performed by ERM, Inc., revealed that ground water at the site occurs in two flow systems consisting of the following three components: a system in the glacial overburden consisting of a shallow zone of a perched ground water component less than twenty feet deep; a deeper flow system component at the glacial till/bedrock interface; and a regional flow system in the underlying bedrock aquifer.

TABLE 4-2
RELATIVE IMPORTANCE OF PROCESSES
INFLUENCING THE FATE OF INDICATOR CHEMICALS (12,15)

Compound	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation	Oxidation
Trichloroethylene	-	+	?	-	-	-	-
trans-1,2-Dichloroethylene	-	+	?	-	-	-	-
Vinyl Chloride	-	+	?	-	-	-	-
Benzene	+	+	-	-	-	-	-

Key to symbols:

- + could be important fate process
- not likely to be an important fate process
- ? importance of fate process uncertain or not known

AR301111

Hydraulic connection among the three flow system components is limited by the presence of a dense glacial till directly overlying bedrock. Flow in the overburden systems is principally lateral, generally toward the east and west from a topographic high beneath the Bendix plant. However, some limited leakage of water downward between flow systems does occur, evident by the low VOC concentrations detected in the regional aquifer. The Village of South Montrose residents use the bedrock aquifer for water supply via domestic wells, and Bendix uses it for process and potable water via production wells.

The ground water contamination is concentrated in the shallow flow zone, where it ranges from a few hundred to hundreds of thousands of ppb beneath the plant property. Beneath the west parking lot, gravel fill material is present that contains several thousand ppb of volatile organics. In this area, volatile organics of up to 1,000 ppb have been shown to have migrated vertically to the top of bedrock flow zone and from there to the bedrock aquifer, where the concentrations are 100 to 150 ppb. In the bedrock system, the contaminants have migrated southwestward along a bedrock fracture.

In the eastern section of the site, volatile organics up to several hundred thousand ppb are present in the shallow flow zone at the former pit disposal site. There appears to be very limited downward migration of contaminants in this area due to restrictions on flow through a thick unsaturated glacial till. However, VOC concentrations of several thousand ppb have been detected in the top of the bedrock flow zone at one location.

4.2.2.2 Soil

The soils investigations indicated that volatile organics are present in the shallow zone of ground water flow in the source areas at the plant, both in the vapor and water phases, and adsorbed on the soil. The contamination decreases quickly with depth, and the restriction of high ppm concentrations to the upper weathered zone in the potential source areas strongly suggests that the unweathered zone of dense silt matrix glacial till vertically limits contaminant migration. Thus, it has been determined that the soil contamination of potential concern is limited to the upper ten to twenty feet of soil (10). These soils may be considered as a continuing source of ground water contamination, although their effect on the regional ground water is limited by the intervening presence of the unweathered glacial till.

4.2.2.3 Surface Water

The initial hydrogeologic investigation found no volatile organics in a marsh located on the eastern portion of the site, which forms the headwaters of Meshoppen Creek. Wyalusing Creek is a headwater stream which crosses the western property boundary of the site; the headwaters area of the Wyalusing Creek watershed was dry during the initial field investigation. Since the stream could be a discharge area for the ground water contamination beneath the parking lot, ERM recommended that samples be taken during the wet season from the parking lot drain pipe and that three samples be taken from selected locations in the stream itself. This sampling and analysis was performed and indicated

the presence of low levels of trichloroethylene and trans-1,2-dichloroethylene at the point of discharge. Samples taken downstream exhibited lower concentrations. Samples of pond water have also been analyzed. This sampling also indicated the presence of low levels of trichloroethylene and trans-1,2-dichloroethylene.

Additional surface water samples were collected and analyzed as part of the Supplemental Remedial Investigation. The results correlate with those reported above, indicating the presence of low levels of trichloroethylene and trans-1,2-dichloroethylene in surface waters.

4.2.2.4 Air

Minimal air monitoring data have been required by the EPA at the site, since all of the contamination is subsurface. As part of the RI, Organic Vapor Analyzer (OVA) readings were taken in each of the four suspected source areas, the TCE Storage Area, the former solvent evaporation area, the old landfill area, and the former pit/trench disposal area. Two background OVA readings were taken as well. No detectable concentrations of VOCs above background concentrations were observed. Also, no odors were noted, and in the absence of disturbance of contaminated soils, volatilization of contaminants and subsequent transport by air is not expected to be an exposure pathway. Those volatiles at the land surface, thus available for volatilization, have already volatilized.

4.3 Exposure Analysis

Analysis of exposure includes identification of the points of exposure, the populations potentially exposed, and the concentrations of the indicator chemicals at those points. Estimates can then be made of the present impact on public health.

4.3.1 Identification of Points of Exposure

The sources of contamination and the applicable transport mechanisms have been evaluated to define the following potential points of exposure for the Bendix Aerospace Site:

1. Consumption of and/or dermal exposure to ground water, and/or inhalation of contaminants following volatilization from ground water, downgradient of the Bendix site.
2. Direct contact with or inhalation of contaminants following volatilization from contaminated soils.
3. Direct contact with or inhalation of contaminants from surface waters.

4.3.2 Populations Potentially Exposed

Populations with potential for exposure are identified as follows, for points of exposure along each potential pathway.

4.3.2.1 Regional Aquifer

The regional bedrock aquifer is an active source of water supply via domestic wells and Bendix production wells. Thus, the populations potentially exposed are the residents of South Montrose and Bendix Aerospace employees. Concentrations from not detectable to 280 ppb of trichloroethylene have been detected in monitoring wells in the bedrock aquifer.

Of the total residents of South Montrose, less than 100 are in the actual VOC plume area, thus limiting the residential population potentially exposed. Carbon filtration units have been installed, maintained, and monitored on those residential wells most affected by the VOC plume, thus limiting exposure. Concentrations ranging from not detectable to a maximum 29 ppb of trichloroethylene have been detected in the residential wells. Another potentially exposed population is the Bendix Aerospace employees. The ground water used in the plant is processed through carbon filtration, thus limiting worker exposure. Overall the Bendix plant employs approximately 700 people.

4.3.2.2 Soils

As previously discussed, subsurface soils do not contribute volatile organics to the air at present. The active production area of the plant is fenced, limiting access to this area to Bendix employees.

4.3.2.3 Surface Waters

Some low ppb levels of exposure could be contributed by surface water in the two plant ponds (through direct contact or volatilization), their discharge to the swamp, or by the western discharge from beneath the parking lot. Populations at potential risk include workers on the Bendix property, the population of the Village of South Montrose, and aquatic populations where discharge occurs to marsh or stream areas.

4.3.3 Exposure Point Concentrations

Potential exposure concentrations for each Indicator Chemical have been determined for each exposure point. For quantitative assessment of public health and environmental risks, both short-term and long-term release concentrations were calculated for each indicator chemical at each exposure point. Long-term releases are defined as the release rates of each contaminant migrating from the site as averaged over an assumed 70-year human lifetime. Short-term contaminant releases are defined, for public health assessment purposes (7), as those that occur over a short period (usually 10 to 0 days) during the first year following site investigation (since it is expected that release rates will decrease over time as the on-site contaminant reservoir decreases). All monitoring data used to determine exposure point concentrations are presented in Appendix E. Short- and long-term exposure point concentrations for each Indicator Chemical are presented for each exposure point/pathway as follows.

4.3.3.1 Regional Aquifer

The underlying bedrock aquifer serves as the local source of water supply, and as such is the aquifer of concern. The migration of volatile organics in the bedrock flow system has been well-defined by the ERM analyses from the on-site wells and domestic wells sampled in the Village of South Montrose. Exposure point concentrations have been defined using the results of those analyses. The data collected have indicated that the VOC plume is near a "steady state" condition, and that dilution, advection, dispersion and reaction mechanisms are producing consistent concentration distributions in the aquifer with time. As such, modeling to determine future concentration increases and downgradient plume advancement is not needed. Because ground water flow in the regional aquifer is both to the east and to the west from a hydraulic divide beneath the Bendix plant, these two components of flow shall be addressed separately.

Regional Aquifer - West

The western plume shows the highest VOC concentrations beneath and adjacent to the parking lot area west of the plant, with the concentration highest (280 ppb) at monitoring well 84-9. VOCs migrate through the overlying glacial till flow system beneath the west parking lot near the western edge of the plant property boundary to the bedrock flow system, which is used as a domestic water supply by the Village of South Montrose. Here the deep and shallow glacial flow components are directly hydraulically connected by full saturation, and merge as the bedrock surface rises to within twenty feet of the land surface. The

concentration of volatile organics in ground water at the top of bedrock is in the several hundred ppb range. Thus, it is in this area that the significant concentrations of volatile organics have reached the bedrock interface where downward recharge carries them to the underlying water table.

The hydrogeologic investigation has shown that the former TCE storage tank area is the source area for the plume, which has migrated to the South Montrose domestic wells from the TCE tank area. Lateral flow in the perched flow zone predominates westward to the parking lot area where infiltration of ground water containing volatile organics into the bedrock aquifer occurs. The bedrock system plume is rapidly diluted to the southwest, becoming non-detectable approximately 600 feet downgradient.

The domestic wells have been sampled quarterly since September 1984, and carbon filters installed when TCE was detected. Dual filters were installed on six of the domestic wells in November 1984. To date, a total of eighteen wells has been fitted with carbon filters under this program. A long-term monitoring program is in place to continue with these measures. The use of carbon filters on affected potable water wells leaves the population potentially exposed to indicator chemical concentrations of less than 1 ppb for both trichloroethylene and trans-1,2-dichloroethylene.

The data used to determine short- and long-term exposure concentrations include untreated water data from residential wells 2 through 8, 11 through 28, 31 through 44, and bedrock

wells 84-9, 84-10, 84-12, MW-6, and AW-1. The short-term concentrations are 280 ppb for trichloroethylene and 0 ppb for trans-1,2-dichloroethylene. Average (long-term) concentrations are 4.98 ppb for trichloroethylene and 0 ppb for trans-1,2-dichloroethylene. The concentrations have been calculated from monitoring data from the residential and bedrock aquifer wells specified.

Regional Aquifer - East

East of the surface topographic divide, total volatile organics have been detected in the bedrock aquifer with a maximum of 100 ppb of VOCs at Production Well No. 4, farthest to the east. To the southeast, up to 41 ppb VOCs were detected at a domestic well. The VOCs detected at the top of bedrock east of the pit/trench disposal area are the likely source of the volatile organics in the bedrock system in this area. Although the natural flow direction in the bedrock system would be due east, the RI has shown that the pumping of the Bendix wells and the domestic wells have drawn the volatile organics southeastward where they have been diluted to the low concentrations detected.

Installation of dual carbon filters on affected domestic wells was carried out as previously described for the western area. In addition, the Bendix water supply system has been provided with carbon filtration. Since the eastern plume is monitored under the same program as the western one, carbon filtration units are subject to the same quality control procedures.

The data used to determine short- and long-term exposure concentrations include raw water monitoring data from residential wells 1, 2, 10, 29, and 30, and bedrock wells 84-1, PW-2, PW-3, and PW-4. The short-term concentrations are 100 ppb for trichloroethylene and 3 ppb for trans-1,2-dichloroethylene. The average (long-term) concentrations are 6.45 ppb for trichloroethylene and 0.115 ppb for trans-1,2-dichloroethylene. These concentrations have been calculated from monitoring data from the residential and bedrock aquifer wells specified.

As described in Section 2, data from the Supplemental Remedial Investigation indicate that the levels of vinyl chloride in the shallow aquifer in the area of the Old Landfill are increasing. Therefore, there is the potential for migration of vinyl chloride into the East portion of the regional aquifer. The short-term and long-term exposure point concentrations for vinyl chloride are both 7 ppb. As described in Section 2, this concentration was based on the maximum concentration of vinyl chloride detected diluted into the deep regional aquifer.

4.3.3.2 Soils

Direct contact with contaminated soils at the site is unlikely, due to the absence of contamination in the surface soil layer.

Potential exposure via volatilization can be assessed by estimating an emission (or release) rate of contaminants from the soil. The emission rate can be calculated for each of the indicator chemicals as follows:

$$E_i = \frac{DC_s A}{(d^2 + 2Dt)^{1/2}}$$

where:

E_i = emission rate of component i, (g/sec)

A = contaminated surface area (cm²)

C_s = the liquid phase concentration of component i in the soil, (g/cm³)

t = time measured from sampling time (seconds)

d = depth of dry zone at time of sampling time (cm)

D = calculated phase flux rate of contaminant i (cm²/sec)

Calculation of E_i for the VOCs of concern yielded values of zero, due to low concentrations (C_s), age of spillage (represented indirectly through t), and large depth of the dry zone (d). Concentrations are therefore assumed to be zero for both trichloroethylene and benzene.

4.3.3.3 Surface Waters

There is potential for contact with surface waters in the ponds, stream, and marsh areas. The short-term concentrations are 400 ppb for trichloroethylene and 50 ppb for

trans-1,2-dichloroethylene. The average (long-term) concentrations are 60.1 ppb for trichloroethylene and 6.25 ppb for trans-1,2-dichloroethylene. These concentrations were determined from surface water monitoring data from the drain effluent, stream, and ponds.

4.4 Maximum Extent of Potential Exposure

4.4.1 Methodology

Exposure is defined as the amount of chemical contacting body boundaries (skin, lungs, or gastrointestinal tract). Exposure calculation considers the following characteristics:

- how often receptors come into contact with contaminants in each specific environmental medium,
- the mode of such contact, and
- the amount of contaminated medium that contacts internal or external body surface during each exposure event.

The goal of the analysis is to quantify the amount of contaminant contacted within a given time interval.

Short-term and long-term exposures are calculated in the same manner. First, for each exposure scenario under consideration, an exposure per event is developed. This exposure value quantifies the amount of contaminant contacted during each exposure event, with "event" being defined differently depending

on the nature of the scenario under consideration (e.g., each day's inhalation of contaminated air constitutes an inhalation exposure event). Event-based exposure estimates take into account the concentration of contaminant in the medium via which exposures occur, the rate of contact with such medium (inhalation rate, ingestion rate, etc.), and the duration of each event.

Event-based exposure values are converted to final intake values by multiplying the exposure per event by the frequency of exposure events over the time frame being considered. Short-term exposure is based on the number of exposure events that occur during the short-term time frame (10 to 90 days), while long-term exposures are based on the number of events that occur within an assumed 70-year lifetime.

For purposes of risk characterization to be performed later, estimates of daily intakes of contaminants are necessary. Daily intake estimates are expressed in terms of mass of contaminant per unit of body mass per day, by dividing daily exposures by the value of the total body mass of an average individual in the receptor population (for such studies, an average adult body mass of 70 kg is assumed for this conversion).

In the assessment, three routes of exposure are applicable: ingestion of contaminants in solution, inhalation of volatilized contaminants, and dermal exposure to contaminants. The following calculation processes were used for each exposure mechanism, as per EPA OSWER Directive 9285.5-1 (8).

Two types of intakes were calculated: subchronic and chronic. The Subchronic Daily Intake (SDI) is the projected human intake of a chemical averaged over a short time period, and it is calculated by multiplying peak concentrations by human intake and body weight factors. It is used for subchronic risk characterization.

Chronic Daily Intake (CDI) is the projected human intake of a chemical averaged over 70 years, and is calculated by multiplying long-term concentrations by human intake and body weight factors. It is used for chronic risk characterization.

All intakes are calculated for a 70 kg adult with the following exposure parameters:

<u>Parameter</u>	<u>Standard Value</u>
Amount of water ingested daily	2 liters
Amount of air breathed	0.83 m ³ /hr
Amount of volatilized substance inhaled while showering or bathing	5.95 liters x concentration
Immersed surface area and length of exposure while bathing	0.8 x 18150 cm ² for 20 minutes
Dermal exposure per year for day recreational use of surface water (adjusted for expected use of Wyalusing Creek; represents a highly conservative and unlikely exposure scenario)	18,150 cm ² for 1.5 hrs per
Mass flux rate for water across skin	0.5 mg/cm ² /hr

4.4.1.1 Inhalation Exposures

Inhalation exposures per event are estimated based on the hours per event, the inhalation rate of the exposed individual during the event, and the concentration of contaminant in the air

breathed. The following formula is used for calculation of event-based exposure:

$$IEX = D \times I \times C$$

where

IEX = estimated inhalation exposure per event (mass of contaminant per event)

D = duration of an exposure event (hours per event)

I = average inhalation rate of exposed persons (cubic meters per hour)

C = contaminant air concentration throughout the exposure period (milligrams per cubic meter of contaminated air)

Short-term exposure is calculated using the short-term contaminant air concentration, and long-term exposure is based on the long-term concentration.

This approach is conservative and assumes that 50 percent of the inhaled contaminant can be absorbed through the lung.

4.4.1.2 Dermal Exposure

Dermal exposure is determined by the concentration of hazardous substance in a contaminated medium that is contacted, the extent of contact (i.e., the body surface area contacted), and the

duration of such contact. For exposure to contaminated water, dermal exposure per event is calculated as follows:

$$\text{DEX} = D \times A \times C \times \text{Flux}$$

where

DEX = estimated dermal exposure per event (mass of contaminant per event)

D = duration of an exposure event (hours per event)

A = skin surface area available for contact (cm²)

C = contaminant concentration in water (weight fraction)

Flux = flux rate of water across skin (mass/cm²/hr)

Subchronic dermal exposure per event is calculated using the short-term contaminant concentrations in water, and chronic exposure is based on the long-term contaminant concentrations. Again, this methodology is conservative since it assumes that the contaminant is absorbed through the skin at the same rate as water.

4.4.1.3 Ingestion Exposure (Water)

Event-based water ingestion exposure equals the daily total amount of contaminant ingested. This is determined by the

contaminated concentration in the water and the amount of water ingested per day using the following quation:

$$INEX = Q \times C$$

Where

INEX = estimated ingestion exposure per event (mass of contaminant per event)

Q = quantity of water ingested (liters)

C = contaminant concentration in water (weight fraction)

4.4.2 Exposure and Daily Intake Calculations

Exposures and daily intakes received under ambient conditions are presented in Table 4-3 by exposure pathway. Table 4-4 presents the total subchronic and chronic daily intakes for potentially exposed populations using the eastern portion of the regional aquifer and for potentially exposed populations using the western portion of the regional aquifer.

**TABLE 4-3
POTENTIAL EXPOSURES FOR AMBIENT CONDITIONS**

Remedial Alternative	Exposure Media	Route of Exposure	Chemical	Short Term Concentration (ppb)	Long Term Concentration (ppb)	Subchronic Intake (mg/kg/day)	Chronic Intake (mg/kg/day)
Ambient	Regional Aquifer East	Inhalation	Trichloroethylene	1.00E+02	6.45E+00	8.50E-03	5.48E-04
			trans-1,2-Dichloroethylene	3.00E+00	1.15E-01	2.55E-04	9.78E-06
			Vinyl Chloride	7.00E+00	7.00E+00	5.95E-04	5.95E-04
		Dermal Contact	Trichloroethylene	1.00E+02	6.45E+00	3.42E-07	2.21E-08
			trans-1,2-Dichloroethylene	3.00E+00	1.15E-01	1.03E-08	3.94E-10
			Vinyl Chloride	7.00E+00	7.00E+00	2.40E-08	2.40E-08
	Regional Aquifer West	Ingestion	Trichloroethylene	1.00E+02	6.45E+00	2.86E-03	1.84E-04
			trans-1,2-Dichloroethylene	3.00E+00	1.15E-01	8.57E-05	3.29E-06
			Vinyl Chloride	7.00E+00	7.00E+00	2.00E-04	2.00E-04
		Inhalation	Trichloroethylene	2.80E+02	4.98E+00	2.38E-02	4.23E-04
			trans-1,2-Dichloroethylene	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Soils	Dermal Contact	Trichloroethylene	2.80E+02	4.98E+00	9.58E-07	1.70E-08
			trans-1,2-Dichloroethylene	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Ingestion	Trichloroethylene	2.80E+02	4.98E+00	8.00E-03	1.42E-04
			trans-1,2-Dichloroethylene	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Surface Water	Inhalation	Trichloroethylene	0.00E+00	0.00E+00	0.00E+00	0.00E+00
			Benzene	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Dermal Contact	Trichloroethylene	4.00E+02	6.01E+01	6.22E-06	3.84E-07
			trans-1,2-Dichloroethylene	5.00E+01	6.25E+00	7.78E-07	4.00E-08

TABLE 4-4
TOTAL POTENTIAL SUBCHRONIC AND CHRONIC EXPOSURES FOR AMBIENT CONDITIONS
FOR BOTH EAST AND WEST AQUIFER USE SCENARIOS

Subchronic Intake Totals (mg/kg/day):			
Regional Aquifer East Scenario	Inhalation		
		Trichloroethylene	8.50E-03
		trans-1,2-Dichloroethylene	2.55E-04
		Vinyl Chloride	5.95E-04
		Benzene	0.00E+00
Dermal Contact		Trichloroethylene	6.57E-08
		trans-1,2-Dichloroethylene	7.88E-07
		Vinyl Chloride	2.40E-08
Ingestion		Trichloroethylene	2.86E-03
		trans-1,2-Dichloroethylene	8.57E-05
		Vinyl Chloride	2.00E-04
Subchronic Intake Totals (mg/kg/day):			
Regional Aquifer West Scenario	Inhalation		
		Trichloroethylene	2.38E-02
		trans-1,2-Dichloroethylene	0.00E+00
		Vinyl Chloride	NA
		Benzene	0.00E+00
Dermal Contact		Trichloroethylene	7.18E-08
		trans-1,2-Dichloroethylene	7.78E-07
		Vinyl Chloride	NA
Ingestion		Trichloroethylene	8.00E-03
		trans-1,2-Dichloroethylene	0.00E+00
		Vinyl Chloride	NA

NA - Not applicable

TABLE 4-4 (Continued)
TOTAL POTENTIAL SUBCHRONIC AND CHRONIC EXPOSURES FOR AMBIENT CONDITIONS
FOR BOTH EAST AND WEST AQUIFER USE SCENARIOS

Chronic Intake Totals (mg/kg/day):			
Regional Aquifer East Scenario	Inhalation		
		Trichloroethylene	5.48E-04
		trans-1,2-Dichloroethylene	9.78E-06
		Vinyl Chloride	5.95E-04
Dermal Contact		Benzene	0.00E+00
		Trichloroethylene	4.06E-07
		trans-1,2-Dichloroethylene	4.04E-08
		Vinyl Chloride	2.40E-08
Ingestion		Trichloroethylene	1.84E-04
		trans-1,2-Dichloroethylene	3.29E-06
		Vinyl Chloride	2.00E-04
Chronic Intake Totals (mg/kg/day):			
Regional Aquifer West Scenario	Inhalation		
		Trichloroethylene	4.23E-04
		trans-1,2-Dichloroethylene	0.00E+00
		Vinyl Chloride	NA
Dermal Contact		Benzene	0.00E+00
		Trichloroethylene	4.01E-07
		trans-1,2-Dichloroethylene	4.00E-08
		Vinyl Chloride	NA
Ingestion		Trichloroethylene	1.42E-04
		trans-1,2-Dichloroethylene	0.00E+00
		Vinyl Chloride	NA

NA - Not applicable

SECTION 5

RISK CHARACTERIZATION

This section assesses the potential risks to human health and the environment associated with exposure to the various indicator compounds, under the remedial alternative of "Ambient Conditions," or existing conditions, at the site. The risks of exposure to carcinogens and noncarcinogens were assessed separately through the following comparisons:

1. current media point concentrations to potentially applicable or relevant and appropriate requirements,
2. current exposure point intakes calculated in Section 4 to acceptable intakes for noncarcinogens, and
3. calculated risks with acceptable risks for potential carcinogens.

5.1 Applicable and Relevant Standards

At this point in the assessment the media concentrations of all compounds detected at the site should be compared to potentially applicable or relevant and appropriate requirements (as defined by the National Contingency Plan (NCP) and identified in the CERCLA compliance policy memo that is an appendix to the

NCP). At the present time, EPA considers drinking water maximum contaminant levels (MCLs), national ambient water quality criteria (WQC), national ambient air quality standards (NAAQS), and federally-approved state water quality standards developed under the Clean Water Act to be potentially applicable or relevant and appropriate ambient concentration requirements. The standards potentially applicable to this site are listed (where available) in Table 5-1.

In the regional aquifer, the maximum detected values for benzene and trichloroethylene exceed their MCLs. However, the average concentration of benzene meets its MCL while the average concentration of trichloroethylene exceeds its MCL. The predicted value of vinyl chloride that could potentially reach the regional aquifer also exceeds the MCL. All other levels of compounds detected in the regional aquifer meet their potential ARARs.

The maximum detected values of benzene, chloroform, and trichloroethylene in surface water exceed the Ambient Water Quality Criteria (AWQC) for the protection of human health for ingesting water and organisms. Only trichloroethylene, however, exceeds its criteria on the average. The maximum detected value, not the average concentration, of trichloroethylene in surface water exceeds the AWQC for protection of human health for ingesting organisms only. It should be noted that the receiving stream, the headwaters of Wyalusing Creek, is intermittent, with no use of water or aquatic organisms for human consumption. The maximum detected value of trans-1,2- dichloroethylene in surface water exceeds the AWQC for protection of aquatic life for acute toxicity. All other levels of compounds detected in surface water meet their potential ARARs.

TABLE 5-1
POTENTIALLY APPLICABLE OR RELEVANT AND
APPROPRIATE REQUIREMENTS

Indicator Chemical	EPA MCL	EPA MCLG	Ambient Water Quality Criteria*			NAQS	State Water Quality Standard
			Fish and Drinking Water	Fish Only	Protection of Aquatic Life		
Benzene	5 µg/L	0	0.66 µg/L	40 µg/L	5.3 mg/L(A)	NS	NS
Carbon tetrachloride	5 µg/L	0	0.4 µg/L	6.94 µg/L	35.2 mg/L(A)	NS	NS
Chloroform**	0.1 mg/L	NS	0.19 µg/L	15.7 µg/L	28.9 mg/L(A)	NS	NS
1,1-Dichloroethane	NS	NS	NS	NS	NS	NS	NS
trans-1,2-Dichloroethylene	NS	70 µg/L	NS	NS	11.6 mg/L(A)	NS	NS
Ethylbenzene	NS	0.68 mg/L	1.4 mg/L	3.28 mg/L	32 mg/L(A)	NS	NS
Methylene chloride	NS	NS	NS	NS	NS	NS	NS
PCBs	NS	0	7.9E-5 µg/L	7.9E-5 µg/L	0.014 µg/L(C)	NS	NS
Tetrachloroethylene	NS	0	0.8 µg/L	8.85 µg/L	0.84 mg/L(C)	NS	NS
Toluene	NS	2 mg/L	14.3 mg/L	424 mg/L	17.5 mg/L(A)	NS	NS
1,1,1-Trichloroethane	0.2 mg/L	0.2 mg/L	18.4 mg/L	1030 mg/L	9.4 mg/L(C)	NS	NS
Trichloroethylene	5 µg/L	0	2.7 µg/L	80.7 µg/L	21.9 mg/L(C)	NS	NS
Vinyl Chloride	2 µg/L	0	2 µg/L	525 µg/L	NS	NS	NS

Key:

NS - No standard or guidance value

(A) Acute

(C) Chronic

Note:

**Standards and guidance for total trihalomethanes

AR301135

5.2 Noncarcinogenic Risk

When all compounds do not have applicable or relevant and appropriate requirements, the technique used for assessing the overall potential for noncarcinogenic effects posed by multiple chemicals is the Hazard Index method. This approach assumes that multiple subthreshold exposures could result in an adverse effect and that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures. This can be expressed in the following equation:

$$\text{Hazard Index} = E_1/AL_1 + E_2/AL_2 + . . . + E_i/AL_i$$

where E_i = Exposure level (or intake) for the i^{th} toxicant

AL_i = Acceptable level (or intake) for the i^{th} toxicant

For a single contaminant, there may be a potential adverse health effect when the hazard index exceeds unity. For multiple chemical exposures, hazard indices, if summed, may result in the overall hazard index that exceeds one, even if no single chemical exceeds its acceptable level. However, the assumption of additivity should be made only for compounds that produce the same toxic effect by the same mechanisms of action. EPA has developed some preliminary information regarding Acceptable Intakes for Subchronic Exposures (AISs) and Acceptable Intakes for Chronic Exposures (AICs)(7). Where these are available, they

are used as acceptable levels for subchronic and chronic exposures, respectively.

Assessment of noncarcinogenic risk, both subchronic and chronic, for existing site conditions under both East and West Aquifer use scenarios is present in Table 5-2. The subchronic hazard index at 1.26×10^{-3} and the chronic hazard index at 1.31×10^{-3} for the East Aquifer Scenario are below the EPA acceptable level of one. The subchronic hazard index at 2.86×10^{-6} and the chronic index at 4.00×10^{-6} for the West Aquifer scenario are below the EPA acceptable level of one. Therefore, the noncarcinogenic health risks at the Bendix facility are generally acceptable.

5.3 Carcinogenic Risk

For potential carcinogens, risks are estimated as probabilities. The carcinogenic potency factor, which is the upper 95% confidence limit of the probability of a carcinogenic response per unit intake over a lifetime of exposure, converts estimated CDIs directly to incremental risk values. In general, because only relatively low CDIs are likely to result from environmental exposures, it is assumed in the EPA methodology that the exposure will be in the linear portion of the dose-response curve. Based on this assumption, the slope of the dose-response curve is equivalent to the carcinogenic potency factor, and the risk is directly related to the CDI at low levels of exposure. The following is the low-dose carcinogenic risk equation:

$$\text{Risk} = \text{CDI} \times \text{Carcinogenic potency factor}$$

TABLE B-2
CALCULATION OF NONCARCINOGENIC HAZARD INDICES
FOR BOTH EAST AND WEST AQUIFER USE SCENARIOS

Remedial Alternative	Route of Exposure	Chemical	Subchronic Daily Intake (mg/kg/day)	Acceptable Intake Subchronic (mg/kg/day)	Subchronic Hazard Index	Chronic Daily Intake (mg/kg/day)	Acceptable Intake Chronic (mg/kg/day)	Chronic Hazard Index
Ambient Regional Aquifer East	Inhalation	Trichloroethylene	8.50E-03	NA	9.38E-04	5.48E-04	NA	9.78E-04
		trans-1,2-Dichloroethylene	2.55E-04	2.72E-01		9.78E-06	1.00E-02	
		Vinyl Chloride	5.95E-04	NA		5.95E-04	NA	
		Benzene	0.00E+00	NA		0.00E+00	NA	
	Dermal Contact	Trichloroethylene	6.57E-06	NA	2.90E-06	4.06E-07	NA	4.04E-06
		trans-1,2-Dichloroethylene	7.88E-07	2.72E-01		4.04E-08	1.00E-02	
		Vinyl Chloride	2.40E-08	NA		2.40E-08	NA	
	Ingestion	Trichloroethylene	2.86E-03	NA	3.15E-04	1.84E-04	NA	3.29E-04
		trans-1,2-Dichloroethylene	8.57E-05	2.72E-01		3.29E-06	1.00E-02	
		Vinyl Chloride	2.00E-04	NA		2.00E-04	NA	
Ambient Regional Aquifer West	Inhalation	Trichloroethylene	2.38E-02	NA	0.00E+00	4.23E-04	NA	0.00E+00
		trans-1,2-Dichloroethylene	0.00E+00	2.72E-01		0.00E+00	1.00E-02	
		Vinyl Chloride	NA	NA		NA	NA	
		Benzene	0.00E+00	NA		0.00E+00	NA	
	Dermal Contact	Trichloroethylene	7.18E-06	NA	2.86E-06	4.01E-07	NA	4.00E-06
		trans-1,2-Dichloroethylene	7.78E-07	2.72E-01		4.00E-08	1.00E-02	
		Vinyl Chloride	NA	NA		NA	NA	
	Ingestion	Trichloroethylene	8.00E-03	NA	0.00E+00	1.42E-04	NA	0.00E+00
		trans-1,2-Dichloroethylene	0.00E+00	2.72E-01		0.00E+00	1.00E-02	
		Vinyl Chloride	NA	NA		NA	NA	
Regional Aquifer East Scenario			Total subchronic hazard index =		1.26E-03	Total chronic hazard index =		1.31E-03
Regional Aquifer West Scenario			Total subchronic hazard index =		2.86E-06	Total chronic hazard index =		4.00E-06

NA - Not applicable

Once an estimate of risk has been obtained, the question arises as to what level of risk is acceptable. The EPA Office of Emergency and Remedial Response (OERR) is currently developing a strategy which will articulate the general framework on which they suggest ground water cleanup decisions be based. In this framework, it is advised that at least one remedial alternative be developed at a site which would attain applicable and appropriate health standards for carcinogens where they are available or a 10^{-6} risk level for carcinogens without standards for current and potential exposure. Such an alternative should be designed to attain these levels within a short period of time and should be used as a point of departure in analyzing a range of alternatives. A target range for all alternatives should be the 10^{-7} to 10^{-4} risk range (EPA's Ground Water Protection Strategy, August 1984).

Assessment of potential carcinogenic effects for existing site conditions under both East and West Aquifer use scenarios is presented in Table 5-3. The calculated carcinogenic risk level for ambient conditions at the Bendix facility is approximately 5×10^{-4} for the bedrock East Aquifer scenario. This risk is above current EPA guidelines for evaluating acceptable risk associated with potential exposures at CERCLA sites. However, this risk may be an over-estimate due to consideration of vinyl chloride migration to the potable aquifer. To date, vinyl chloride has not been detected in the regional aquifer. The calculated carcinogenic risk level for ambient conditions at the Bendix facility is approximately 4×10^{-6} for the West Aquifer scenario. This risk can be considered generally acceptable, within the EPA goal range of 1×10^{-7} to 1×10^{-4} .

TABLE 5-3
CALCULATION OF RISK FROM POTENTIAL CARCINOGENS
FOR BOTH EAST AND WEST AQUIFER USE SCENARIOS

Remedial Alternative	Route of Exposure	Chemical	Chronic Daily Intake (mg/kg/day)	Carcinogenic Potency Factor (mg/kg/day) ⁻¹	Route/Chemical Specific Risk
Ambient Regional Aquifer East	Inhalation	Trichloroethylene	5.48E-04	4.60E-03	3E-06
		trans-1,2-Dichloroethylene	9.78E-06	NA	
		Vinyl Chloride	5.95E-04	2.50E-02	1E-05
		Benzene	0.00E+00	2.60E-02	0E+00
	Dermal Contact	Trichloroethylene	4.06E-07	1.10E-02	4E-09
	Ingestion	trans-1,2-Dichloroethylene	4.04E-08	NA	
		Vinyl Chloride	2.40E-08	2.30E+00	6E-08
		Trichloroethylene	1.84E-04	1.10E-02	2E-06
		trans-1,2-Dichloroethylene	3.29E-06	NA	
		Vinyl Chloride	2.00E-04	2.30E+00	5E-04
Ambient Regional Aquifer West	Inhalation	Trichloroethylene	4.23E-04	4.60E-03	2E-06
		trans-1,2-Dichloroethylene	0.00E+00	NA	
		Vinyl Chloride	NA	2.50E-02	
		Benzene	0.00E+00	2.60E-02	0E+00
	Dermal Contact	Trichloroethylene	4.01E-07	1.10E-02	4E-09
	Ingestion	trans-1,2-Dichloroethylene	4.00E-08	NA	
		Vinyl Chloride	NA	2.30E+00	
		Trichloroethylene	1.42E-04	1.10E-02	2E-06
		trans-1,2-Dichloroethylene	0.00E+00	NA	
		Vinyl Chloride	NA	2.30E+00	
Regional Aquifer East Scenario					Total Risk = 5E-04
Regional Aquifer West Scenario					Total Risk = 4E-06

NA - Not applicable

5.4 Uncertainty

The EPA employs a great deal of conservatism in the process that it proposes to describe human cancer risks. EPA gives animal test evidence stronger weight than the IARC in determining the strength of evidence that determines whether a substance is a human carcinogen. Additionally, EPA suggests the use of the linear multistage dose-response model to predict human cancer risk at low doses. This model is more conservative than other dose-response models.

EPA suggested methodology in calculating intakes over a lifetime is also conservative. For example, EPA assumes that substances ingested are completely absorbed through the digestive tract, although it is known that only a fraction of the mass behaves this way.

The above mentioned factors in combination lead to a high level of conservatism in the whole risk assessment process. The effect is overestimating risks. The scenarios developed for the Bendix facility follow this philosophy as well.

SECTION 6 CONCLUSIONS

6.1 Background

This report was prepared to evaluate the level of risk under existing conditions at the Bendix facility. Previous reports have evaluated the hydrogeological conditions and the feasibility of various alternatives at the site. After these reports were submitted to EPA, the Agency requested that a Risk Assessment be conducted. This Risk Assessment is, therefore, being applied retroactively to assess the risk associated with existing conditions at the site.

6.2 Methodology

EPA has developed draft guidelines for the preparation of Risk Assessments at hazardous waste sites. These draft guidelines include the Draft Endangerment Assessment Handbook (6), Superfund Public Health Evaluation Manual (7), Draft Superfund Exposure Assessment Manual (8), and Toxicology Handbook (9). This assessment was prepared according to these guidelines.

6.3 Conclusions and Summary

The following conclusions are made based on the analyses performed in this assessment:

- The maximum detected levels of carbon tetrachloride and trichloroethylene and the projected concentration of vinyl chloride in the regional aquifer exceed MCLs.
- The maximum detected levels of benzene, chloroform, and trichloroethylene in surface water exceed their respective Ambient Water Quality Criteria for drinking water and ingestion of organisms.
- The maximum detected level of trichloroethylene in surface water exceeds its Ambient Water Quality Criteria for ingestion of organisms only.
- The maximum detected level of trans-1,2-dichloroethylene exceeds its Ambient Water Quality Criteria for acute protection of aquatic life.
- All other potential ARARs are not violated by existing site conditions.
- The potential noncarcinogenic risk posed by the exposure pathways developed in this risk assessment is acceptable.
- The potential carcinogenic risk posed by the exposure pathways developed in this risk assessment is acceptable except for the potential future projected exposure to vinyl chloride in the eastern portion of regional aquifer.

In summary, ambient site conditions represent an acceptable level of risk, with the exception of projected migration of vinyl chloride from beneath the old landfill area to the regional aquifer. As stated in Section 5, to date no vinyl chloride has been detected in the regional aquifer. However, elimination of the source of contamination represents a desirable action for long-term protection of human health and the environment.

ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AIC	Acceptable Intakes for Chronic Exposures
AIS	Acceptable Intakes for Subchronic Exposures
CAG	Carcinogen Assessment Group - USEPA
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (syn: Superfund)
CNS	Central Nervous System
CPF	Carcinogen Potency Factor
CT	Concentration Times the Toxicity Constant
EA	Endangerment Assessment
EPA	Environmental Protection Agency
ERM	Environmental Resources Management, Inc.
FDA	Food and Drug Administration
FS	Feasibility Study
IARC	International Agency for Research on Cancer of the World Health Organization
ICRP	International Committee for Radiologic Protection
IS	Indicator Score
MCL	Maximum Concentration Level
NAAQS	National Ambient Air Quality Standards
NC	Noncarcinogen
NCP	National Oil and Hazardous Substance Pollution Contingency Program
NIC	National Cancer Institute
NPL	National Priority List
NTP	National Toxicology Program
OERR	Office of Emergency and Remedial Response - USEPA
OSHA	Occupational Safety and Health Administration
PADER	Pennsylvania Department of Environmental Resources
PC	Potential Carcinogen
ppb	Parts per billion
ppm	Parts per million
RA	Risk Assessment
RI	Remedial Investigation
SDI	Subchronic Daily Intake
TLV	Threshold Limit Value
VOCs	Volatile Organic Compounds

AR 301146

REFERENCES

1. US EPA. 1984. U.S. Environmental Protection Agency. Office of Health and Environmental Assessment. Proposed guidelines for carcinogenic risk assessment. Fed. Regist., Nov. 23, 1984, 49:46294-46301.
2. US EPA. 1984. U.S. Environmental Protection Agency. Office of Health and Environmental Assessment. Proposed guidelines for exposure assessment. Fed. Regist., Nov. 23, 1984, 49:46304-46312.
3. US EPA. 1984. U.S. Environmental Protection Agency. Office of Health and Environmental Assessment. Proposed guidelines for mutagenicity risk assessments. Fed. Regist., Nov. 23, 1984, 49:46314-46321.
4. US EPA. 1984. U.S. Environmental Protection Agency. Office of Health and Environmental Assessment. Proposed guidelines for the health assessment of suspect developmental toxicants. Fed. Regist., Nov. 23, 1984, 49:46324-46331.
5. US EPA. 1985. U.S. Environmental Protection Agency. Office of Health and Environmental Assessment. Proposed Guidelines for the Health Risk Assessment of Chemical Mixtures. Fed. Regist., Jan. 9, 1985, 50:1170-1176.
6. US EPA. 1985. U.S. Environmental Protection Agency. Office of Waste Programs Enforcement. Draft Endangerment Assessment Handbook. Prepared by PRC, Environmental Management, Inc.

7. US EPA. 1986. U.S. Environmental Protection Agency. Office of Waste Programs Enforcements. Superfund Public Health Evaluation Manual. Prepared by ICF Incorporated. EPA 540/1-86-060.
8. US EPA. 1986. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response. Office of Solid Waste and Remedial Response. Draft Superfund Exposure Assessment Manual. Prepared by Versar Inc., January 14, 1986.
9. US EPA. 1986. U.S. Environmental Protection Agency. Office of Waste Programs Enforcement. Toxicology Handbook: Principals Related to Hazardous Waste Site Investigation. Prepared by PRC, Environmental Management, Inc. August 1985.
10. ERM, Inc. 1985. Environmental Resources Management, Inc. Hydrogeologic and Soils Investigation at the Bendix Flight Systems Division Facility, South Montrose, PA. January 1985.
11. Mabey, W. R., J. H. Smith, R. T. Podoll, H. L. Johnson, T. Mill, T.W. Chou, J. Gates, I. Waight Partridge, H. Jaber, and D. Vandenberg. 1982. Aquatic Fate Process Data for Organic Priority Pollutants. US EPA, Washington DC, EPA-440/4-81-014.
12. Callahan, M.A., M.W. Slimak, N.W. Gabel, I.P. May, C.F. Fowler, J.R. Freed, P. Jennings, R. L. Durfee, F. C. Whitmore, B. Maestri, W.R. Mabey, B.R. Holt, and C. Gould. 1979. Water-Related Environmental Fate of 129 Priority Pollutants. US EPA, Washington DC. Vol. I, EPA-440/4-79-029a; Vol. II, EPA-440/4-79-029b.
13. Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York.

AR301147



14. Weast, R.C. (editor). 55th Ed., CRC Handbook of Chemistry and Physics. CRC Press. Boca Raton, Florida 1974-1975.
15. Mills, W.B., J. D. Dean, D.B. Porcella, S.A. Gherini, R. J.M. Hudson, W.E. Frick, G.L. Rupp, and G. L. Bowie. 1982. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants. US EPA. Athens, GA. Vol. I, EPA-600/6-82-004a; Vol. II, EPA-600/6-82-004b.
16. US EPA. 1985. U.S. Environmental Protection Agency. Office of Research and Development. Environmental Criteria and Assessment Office. Cincinnati, OH. Health Assessment Document for Trichloroethylene: Final Report. EPA-600/8-82-006F.
17. Gilbert, D., M. Byrne, J. Harris, W. Steber, and C. Woodruff. 1980 with revisions March 1981 and January 1982. An Exposure and Risk Assessment for Benzene. US EPA, Washington, DC. EPA-440/4-85-015.
18. US EPA. 1984. U.S. Environmental Protection Agency. Office of Drinking Water. Washington, D.C. Techniques for the Assessment of the Carcinogenic Risk to the U.S. Population Due to Exposure from Selected Volatile Organic Compounds from Drinking Water. P1384-213941.
19. US EPA. 1984. National Primary Drinking Water Regulations for Volatile Synthetic Organic Chemicals: Proposed Rulemaking. Fed. Reg. 49:24330-24355.
20. ERM, Inc. 1985. Final Report Evaluation of Remedial Alternatives and Recommended Remedial Actions at Allied-Bendix Flight Systems Division, South Montrose, Pa. February 1985.

AR301148



21. Klaassen, C.D., M.D. Amdur, and J. Doull. 1986. Casarett and Doull's Toxicology: The Basic Science of Poisons. MacMillan Publishing Co., New York.
22. US EPA. 1978. U.S. Environmental Protection Agency. Office of Research and Development. Environmental Pathways of Selected Chemicals in Fresh water Systems: Part II. EPA 600/7-78-074.
23. US EPA. 1985. U.S. Environmental Protection Agency. Washington, DC. Health Advisories for 52 chemicals which have been detected in Drinking Water. PB 86-1118338.
24. US EPA. 1985. U.S. Environmental Protection Agency. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites, Final. Prepared by Clement Associates.

APPENDIX A

**SAMPLING DATA USED IN PREPARATION
OF THE BENDIX AEROSPACE
SOUTH MONTROSE, PENNSYLVANIA
ENDANGERMENT ASSESSMENT**

Shallow Glacial Till Aquifer
Deep Glacial Till Aquifer
Bedrock Aquifer
Residential Wells
Surface Water
Soils
Sediments

AR301150



Geography

Q. These sampling results have undergone an EPA Quality Assurance Protocol.

A. Yes. This result is of questionable qualitative significance since this sample collection was not observed in the field of the water collection.

Q. This result should be considered a qualitative estimate.

[illegible]

QUALITY STEAK COOKING

Q - These sampling results have implications on EPA Quality Assurance Program.

B - This result is of questionable quality. Implications under this compensation level was detected in 10% of similar assessment.

J - This result should be considered a questionable estimate.



The ERM Group

AR301153

Well Number	Date Sampled	Total Production	Pressure	Stripper Pressure	Methanol Chloride	Vinyl Chloride	Carbon Tetrachloride	1,1-Dichloro-ethylene	1,1-Dichloro-ethylene	1,1,1-Trichloro-ethylene	1,1,2-Dichloro-ethylene	Chloroform	Bromoform	Trichloro-ethylene	Trichloro-ethylene	1,2-Dibromo-ethylene
84-6	8/14/64	410	30	60	40							10		270		
	11/14/64	722	2		9							7		200		
	4/24/65	8730			110			1			3			8570		
	7/22/65	7300			100						100			7000		
	11/7/65	3140			70						70			2000		
	2/6/66	2750	7		63			2			63	4		2000		
	6/6/66	5000												8400		
	8/6/66	5500												8500		
	11/4/66	4450			60						70			4300		
	Q 10/26/7	2110			60 (8)						40			2070		
84-7	Q 4/24/67	4085	14		100		5	2			97	4		4400		1
	Q 5/26/7	2000			60 (8)						40			1900		
	Q 11/26/7	1440			30 (8)						30			1000		
	8/14/64	60	3													
	11/13/64	900									0	3		65		
	4/24/65	479									20			800		
	7/22/65	430									27	42		410		
	11/7/65	127									30			400		
	2/6/66	1									30	8		60		
	6/6/66	1000												1		
	8/6/66	400									60	100		850		
84-8	11/4/66	135									20	30		430		
	Q 4/24/67	543					6				24	0		100		
	Q 5/26/7	178									11	10		830		
	Q 11/26/7	57									30	3		100		
											40	2		47		

CUM FUND COOPER

- G.** These sampling results have undergone an EPA Quality Assurance Review.

[illegible]

SYMPTOM CHECKLIST

Q - These sampling results have undergone an EPA Quality Assurance Review.

S - This result is of questionable qualitative significance since this compound/concentration was detected in blanks at similar concentrations.

J - This result should be considered a qualitative estimate.

J - This issue should be considered a quarterly article.

1. **Introduction**
 2. **Background**
 3. **Methodology**
 4. **Results**
 5. **Discussion**
 6. **Conclusion**
 7. **References**
 8. **Appendix**
 9. **Figure 1**
 10. **Figure 2**
 11. **Figure 3**
 12. **Figure 4**
 13. **Figure 5**
 14. **Figure 6**
 15. **Figure 7**
 16. **Figure 8**
 17. **Figure 9**
 18. **Figure 10**
 19. **Figure 11**
 20. **Figure 12**
 21. **Figure 13**
 22. **Figure 14**
 23. **Figure 15**
 24. **Figure 16**
 25. **Figure 17**
 26. **Figure 18**
 27. **Figure 19**
 28. **Figure 20**
 29. **Figure 21**
 30. **Figure 22**
 31. **Figure 23**
 32. **Figure 24**
 33. **Figure 25**
 34. **Figure 26**
 35. **Figure 27**
 36. **Figure 28**
 37. **Figure 29**
 38. **Figure 30**
 39. **Figure 31**
 40. **Figure 32**
 41. **Figure 33**
 42. **Figure 34**
 43. **Figure 35**
 44. **Figure 36**
 45. **Figure 37**
 46. **Figure 38**
 47. **Figure 39**
 48. **Figure 40**
 49. **Figure 41**
 50. **Figure 42**
 51. **Figure 43**
 52. **Figure 44**
 53. **Figure 45**
 54. **Figure 46**
 55. **Figure 47**
 56. **Figure 48**
 57. **Figure 49**
 58. **Figure 50**
 59. **Figure 51**
 60. **Figure 52**
 61. **Figure 53**
 62. **Figure 54**
 63. **Figure 55**
 64. **Figure 56**
 65. **Figure 57**
 66. **Figure 58**
 67. **Figure 59**
 68. **Figure 60**
 69. **Figure 61**
 70. **Figure 62**
 71. **Figure 63**
 72. **Figure 64**
 73. **Figure 65**
 74. **Figure 66**
 75. **Figure 67**
 76. **Figure 68**
 77. **Figure 69**
 78. **Figure 70**
 79. **Figure 71**
 80. **Figure 72**
 81. **Figure 73**
 82. **Figure 74**
 83. **Figure 75**
 84. **Figure 76**
 85. **Figure 77**
 86. **Figure 78**
 87. **Figure 79**
 88. **Figure 80**
 89. **Figure 81**
 90. **Figure 82**
 91. **Figure 83**
 92. **Figure 84**
 93. **Figure 85**
 94. **Figure 86**
 95. **Figure 87**
 96. **Figure 88**
 97. **Figure 89**
 98. **Figure 90**
 99. **Figure 91**
 100. **Figure 92**
 101. **Figure 93**
 102. **Figure 94**
 103. **Figure 95**
 104. **Figure 96**
 105. **Figure 97**
 106. **Figure 98**
 107. **Figure 99**
 108. **Figure 100**
 109. **Figure 101**
 110. **Figure 102**
 111. **Figure 103**
 112. **Figure 104**
 113. **Figure 105**
 114. **Figure 106**
 115. **Figure 107**
 116. **Figure 108**
 117. **Figure 109**
 118. **Figure 110**
 119. **Figure 111**
 120. **Figure 112**
 121. **Figure 113**
 122. **Figure 114**
 123. **Figure 115**
 124. **Figure 116**
 125. **Figure 117**
 126. **Figure 118**
 127. **Figure 119**
 128. **Figure 120**
 129. **Figure 121**
 130. **Figure 122**
 131. **Figure 123**
 132. **Figure 124**
 133. **Figure 125**
 134. **Figure 126**
 135. **Figure 127**
 136. **Figure 128**
 137. **Figure 129**
 138. **Figure 130**
 139. **Figure 131**
 140. **Figure 132**
 141. **Figure 133**
 142. **Figure 134**
 143. **Figure 135**
 144. **Figure 136**
 145. **Figure 137**
 146. **Figure 138**
 147. **Figure 139**
 148. **Figure 140**
 149. **Figure 141**
 150. **Figure 142**
 151. **Figure 143**
 152. **Figure 144**
 153. **Figure 145**
 154. **Figure 146**
 155. **Figure 147**
 156. **Figure 148**
 157. **Figure 149**
 158. **Figure 150**
 159. **Figure 151**
 160. **Figure 152**
 161. **Figure 153**
 162. **Figure 154**
 163. **Figure 155**
 164. **Figure 156**
 165. **Figure 157**
 166. **Figure 158**
 167. **Figure 159**
 168. **Figure 160**
 169. **Figure 161**
 170. **Figure 162**
 171. **Figure 163**
 172. **Figure 164**
 173. **Figure 165**
 174. **Figure 166**
 175. **Figure 167**
 176. **Figure 168**
 177. **Figure 169**
 178. **Figure 170**
 179. **Figure 171**
 180. **Figure 172**
 181. **Figure 173**
 182. **Figure 174**
 183. **Figure 175**
 184. **Figure 176**
 185. **Figure 177**
 186. **Figure 178**
 187. **Figure 179**
 188. **Figure 180**
 189. **Figure 181**
 190. **Figure 182**
 191. **Figure 183**
 192. **Figure 184**
 193. **Figure 185**
 194. **Figure 186**
 195. **Figure 187**
 196. **Figure 188**
 197. **Figure 189**
 198. **Figure 190**
 199. **Figure 191**
 200. **Figure 192**
 201. **Figure 193**
 202. **Figure 194**
 203. **Figure 195**
 204. **Figure 196**
 205. **Figure 197**
 206. **Figure 198**
 207. **Figure 199**
 208. **Figure 200**
 209. **Figure 201**
 210. **Figure 202**
 211. **Figure 203**
 212. **Figure 204**
 213. **Figure 205**
 214. **Figure 206**
 215. **Figure 207**
 216. **Figure 208**
 217. **Figure 209**

AR301156

[illegible]

1. **Q** - These sampling results have undergone an EPA Quality Assurance Review.

2. **B** - This result is of questionable qualitative significance since this component is not listed as a constituent in the applicable MCL.

3. **A** - This result should be considered a qualitative estimate.

South Montrose
Volatile Organics in Soil
(All results in ppm)

Boring or Trench	Date	Depth (ft)	Benzene	Toluene	Trans 1,2 Dichloro ethene	Tri- chloro- ethene	Tetra- chloro- ethene	Other	Total	OVA Reading
TCE Tank Area										
T-1	8/10/84	6-8 12-14 30-31.5 40-41.5 50-51.5	.09	.08		6.4 .27 .38 .14 .04			6.55 .27 .38 .14 .04	N.A. N.A. N.A. N.A. N.A.
T-2	8/13/84	2-4 8-10			.17 .09	.04 .08			.21 .17	N.A. N.A.
T-3	8/13/84	4-6 8-10	.05			.84 .14			.64 .19	N.A. N.A.
T-4	8/13/84	2-4 8-10	.36 .07	.07	1.80 .05	8.8 .96			10.56 1.15	N.A. N.A.
T-5	8/13/84	2-4 6-8 8-10				.05 .14			N.D. .05 .14	N.A. N.A. N.A.
T-6	8/13/84	2-4 6-7				.29 .19			.29 .19	N.A. N.A.
Former Drum Storage Area										
P-1	8/7/84	4-5 50-51	.07	.08	.03	.09	.60 .29	.09	.80 .65	N.A. N.A.
P-2	8/8/84	2-4 8-10							N.D. N.D.	N.A. N.A.
P-3	8/8/84	4-6 8-10							N.D. N.D.	N.A. N.A.
P-4	8/8/84	2-4 6-8 8-10	.07	.10		.06 .10	.02		.02 .23 .10	N.A. N.A. N.A.
P-5	8/8/84	4-6 8-10							N.D. N.D.	N.A. N.A.
P-6	8/8/84	2-4 6-8 8-10	.81 .24	.81 .33	.04 .09	.47 .06	.05		2.13 N.D. .77	N.A. N.A. N.A.

Blank or N.D. - Not detected
N.A. - Not analyzed

AR301158



**South Montrose
Volatile Organics in Soil
(All results in ppm)**

Boring or Trench	Date	Depth (ft)	Benzene	Toluene	Trans 1,2 Dichloro ethene	Yt- chloro- ethene	Tetra- chloro- ethene	Other	Total	OVA Reading
Former Distillation System Area										
D-1	8/9/84	2-4	.09	.31					.40	N.A.
		14-16		.14		1.80	.04		2.08	N.A.
		30-31.5				.64			.64	N.A.
		66-70							N.D.	N.A.
D-2	8/8/84	2-4	11.23	1.50	38.0	35.0	13.0	3.90	102.63	N.A.
		6-8	.14	.09		.04	.02		.29	N.A.
		8-10	.07							N.A.
D-3	8/9/84	2-4	57.00	38.0	1.4	5.9	83.0	1.40	184.70	N.A.
		6-10	1.02	1.2		.07	.03		2.32	N.A.
D-4	8/9/84	2-4	.39	.08	.13	.78	.81	.03	2.22	N.A.
		8-10					.02		.02	N.A.
D-5	8/13/84	4-6	10.50	16.00		.05	1.40		27.95	N.A.
		8-10		.12		.05			.17	N.A.
D-6	8/13/84	2-4			.14	1.5	.23	.05	1.92	N.A.
		8-10				.09	.05		.14	N.A.
BT-8	11/15/84	0-2							N.A.	>2000
		2-4							N.A.	1900
BT-9	11/15/84	0-4							N.A.	>2000
		4-5							N.A.	>2000
BT-10	11/15/84	0-2							N.A.	>2000
		2-4							N.A.	>2000
BT-11	11/15/84	0-3			.18	.92	.29	.02	1.41	3.0
		3-5			.13	.43	.39		.95	14.0
BT-12	11/15/84	0-3.5			.34	1.00	.30	.04	1.68	3.70
		3.5-5.0	.06	.10	3.60	2.40	.78	.30	7.08	27.0
BT-13	11/15/84	0-1.5			1.70	1.70	.31	.54	4.25	7.30
		2-4			.05	.05			.10	6.10

Blank or N.D. - Not detected
N.A. - Not analyzed

South Montrose
Volatile Organics In Soil
(All results in ppm)

Boring or Trench	Date	Depth (ft)	Benzenes	Toulene	Trans 1,2 Dichloro ethene	Tr chloro- ethene	Tetra- chloro- ethene	Other	Total	OVA Reading
Landfill Area										
L-1	8/13/84	2-4	.46		.44	3.60			4.70	N.A. N.A.
		6-8								
BT-7	11/15/84	1.5-2			.04	.07			.11	4.70
		2-3								
		2-4								
Pit/Trench Area										
PT-1	8/14/84	0-2				.06			N.D.	N.A. N.A.
		6-8								
PT-2	8/14/84	2-4				.09			.09	N.A. N.A.
		6-8								
PT-3	8/14/84	4-6				.04			.04	N.A. N.A.
		8-10								
PT-4	8/14/84	4-6				.02			N.D.	N.A. N.A.
		8-9								
PT-5	8/14/84	2-4	.06			.04			.10	N.A. N.A. N.A.
		6-8								
		8-10								
PT-6	8/14/84	4-6							N.D.	N.A. N.A.
		6-10								
PT-7	8/14/84	2-4							N.D.	N.A. N.A.
		6-10								
PT-8	8/14/84	2-4	1.02		.69	1.20	.04	.05	3.00	N.A. N.A. N.A.
		6-8								
		6-10								
BT-1	11/14/84	0-2							N.D.	.9 13.0 368.0
		2-4								
		5-7								
BT-2	11/14/84	1.5-2							N.D.	2.6 2.7 2.2
		3-4								
		5-6								

Blank or N.D. - Not detected
N.A. - Not analyzed

AR301-160



South Montrose
Volatile Organics in Soil
(All results in ppm)

Boring or Trench	Date	Depth (ft)	Benzene	Toluene	Trans 1,2 Dichloro ethene	1,4- chloro- ethene	Tetra- chloro- ethene	Other	Total	OVA Reading
BT-3	11/14/84	2-3			.02				.02	4.5
		4-5							N.A.	3.6
		5-6							.03	352.0
BT-4	11/14/84	0-1.5			5.00	93.00	19.00	4.00	126.00	588
		1.5-2							N.A.	1768
		4-5							N.A.	555
		6-7						.03	.56	>2000
BT-5	11/14/84	1-2							N.D.	3.2
		3-4				.06			N.A.	3.3
		6-7							.06	5.3
BT-6	11/15/84	1.5-2.5			.02	.03			.05	31.0
		3-4			.02	.09			.11	28.6

Blank or N.D. - Not detected

N.A. - Not analyzed

AR301161

**South Montrose
Pond Sediment Results
(All results in ppm)**

Station number	Sample location	Date	Ethyl- benzene	Toluene	1,1,2- Trichloro- ethane	Tri- chloro- ethene	Trans-1,2- dichloro thene	Total
PS-1	No. 1 Pond	8/13/84		0.13				0.13
PS-2	No. 2 Pond, S	8/13/84						ND
PS-3	No. 2 Pond, N	8/13/84	0.07	0.19				0.26

Blank or ND - Not detected

AR301162

APPENDIX B

**WORKSHEETS USED IN PREPARATION
OF THE BENDIX AEROSPACE
SOUTH MONTROSE, PENNSYLVANIA
ENDANGERMENT ASSESSMENT**

**Aquatic Media
Terrestrial Media**

AR301163



NAME OF SITE: Bendix - South Montrose
 DATE PREPARED: 11 February 1988
 ANALYST: LB
 VERIFIED BY: SCL
 DATE: 16 June 1988

WORKSHEET 1.
 SCORING FOR INDICATOR CHEMICAL SELECTION:
 CONCENTRATIONS AND Koc VALUES
 IN VARIOUS AQUATIC ENVIRONMENTAL MEDIA.

Chemical	CAS. No.	Koc Value	Ground Water (mg/L)			Residential Wells (mg/L)			Surface Water (mg/L)		
			Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Benzene	71-43-2	83	ND			ND	9.00E-03	4.00E-05	ND	2.00E-03	5.56E-05
Toluene	106-88-3	300	ND	1.00E-03	1.04E-05	ND	5.00E-03	2.91E-05	ND	7.00E-03	4.17E-04
Ethylbenzene	100-41-4	1100	ND			ND	2.00E-03	1.82E-05	ND	1.00E-03	2.78E-05
Methylene Chloride	75-09-2	8.8	ND	6.00E-03	9.38E-05	ND	1.00E-03	1.45E-05	ND		
Carbon Tetrachloride	56-23-5	110	ND	2.50E-02	4.48E-04	ND			ND	1.00E-03	2.78E-05
1,1-Dichloroethane	75-34-3	30	ND	2.00E-03	4.17E-05	ND			ND		
1,1,1-Trichloroethane	71-55-6	152	ND			ND			ND		
Trans-1,2-Dichloroethene	540-59-0	59	ND	3.00E-03	1.15E-04	ND			ND		
Chloroform	67-66-3	31	ND	8.00E-03	1.88E-04	ND			ND		
Trichloroethene	79-01-6	126	ND	2.80E-01	1.81E-02	ND	3.00E-03	2.18E-05	ND	2.00E-03	5.56E-05
Tetrachloroethene	127-18-4	364	ND			ND	2.90E-02	2.00E-03	ND	1.00E-03	1.39E-04
1,2-Dichloroethane	107-06-2	14	ND			ND	3.00E-03	2.91E-05	ND	2.00E-03	6.25E-03
Dibromochloromethane-U	124-48-1		ND			ND	2.00E-03	7.27E-06	ND	5.00E-02	1.39E-04
Chlorobenzene	108-90-7	330	ND			ND	2.00E-03	7.27E-06	ND	4.00E-01	6.01E-02
Vinyl Chloride	75-01-4	57	ND	7.00E-03	7.00E-03	ND	2.00E-03	7.27E-06	ND		
PCBs	1336-36-3	530000	ND	2.00E-06	2.00E-06	ND			ND		

U - Toxicity constants unknown
 ND - Not detected

AR301164

WORKSHEET 2
SCORING FOR INDICATOR CHEMICAL SELECTION:
TOXICITY INFORMATION.

NAME OF SITE: Bendix - South Montrose
DATE PREPARED: 10 February 1988
ANALYST: SCL
VERIFIED BY: LB
DATE: 16 June 1988

CHEMICAL	TOXICOLOGIC CLASS	EPA RATING VALUE		WATER T.C.	SOIL T.C.	AIR T.C.
		ORAL	INHALATION			
Benzene	PC	A	A	7.71E-03	3.86E-07	7.71E-02
	NC	5	10	1.17E-01	5.85E-08	1.18E+02
Carbon Tetrachloride	PC	B2	B2	1.88E+00	9.41E-05	1.88E+01
	NC	10	10	3.17E-01	1.59E-05	3.17E+00
Chlorobenzene	NC	4	1	1.43E-01	7.14E-08	2.79E-01
Chloroform	PC	B2	B2	5.83E-02	2.81E-08	5.83E-01
1,1-Dichloroethane	NC	7	7	2.58E-02	1.29E-08	2.58E-01
1,2-Dichloroethane (EDC)	PC	B2	B2	5.86E-02	2.93E-08	5.86E-01
	NC	10	8	1.76E-02	8.80E-07	1.10E+00
1,2-Dichloroethene (trans)	NC	5	5	5.29E-02	2.85E-08	5.29E-01
Ethylbenzene	NC	4	4	1.10E-02	5.52E-07	1.10E-01
Methylene chloride	PC	B2	B2	NA	NA	NA
	NC	10	10	9.20E-04	4.60E-08	6.20E-03
PCBs	PC	B2	B2	5.71E-01	2.86E-05	5.71E+00
Tetrachloroethylene	PC	B2	B2	8.86E-03	4.43E-07	8.86E-02
	NC	7	10	9.82E-03	4.18E-07	2.75E-02
Toluene	NC	7	7	5.20E-03	2.60E-07	5.20E-02
1,1,1-Trichloroethane	NC	2	2	7.33E-04	3.87E-08	7.33E-03
Trichloroethylene	PC	B2	B2	4.29E-03	2.14E-07	4.29E-02
	NC	5	4	1.05E+00	5.26E-05	2.96E+01
Vinyl Chloride	PC	A	A	4.29E-03	2.14E-07	4.29E-02
	NC	10	10	8.77E-02	4.39E-08	8.77E-01

AR301165



WORKSHEET 3.
SCORING FOR INDICATOR CHEMICAL SELECTION:
CALCULATION OF CT AND IS VALUES FOR CARCINOGENIC EFFECTS
IN AQUATIC MEDIA.

NAME OF SITE: Bendix - South Montrose
 DATE PREPARED: 11 February 1988
 ANALYST: LB
 VERIFIED BY: SCL
 DATE: 16 June 1988

Chemical	Ground Water CT			Residential Wells CT			Surface Water CT			IS Value			Tentative Rank	
	MAX	AVE		MAX	AVE		MAX	AVE		MAX	AVE		MAX	AVE
Benzene	4.70E-02	8.42E-04		6.94E-05	3.08E-07		1.54E-05	4.29E-07		8.48E-05	7.37E-07		5	6
Carbon Tetrachloride	4.50E-04	1.06E-05		1.69E-04	1.23E-06		1.88E-03	5.23E-05		4.89E-02	8.95E-04		1	1
Chloroform	1.20E-03	7.76E-05		1.24E-04	8.58E-06		1.13E-04	7.83E-06		7.32E-04	1.98E-05		3	4
Trichloroethene				2.66E-05	2.58E-07		1.72E-03	2.58E-04		3.04E-03	3.44E-04		2	2
Tetrachloroethene				1.17E-04	4.26E-07					2.66E-05	2.58E-07		7	8
1,2-Dichloroethane	3.00E-05	3.00E-05								1.17E-04	4.26E-07		4	7
Vinyl Chloride	1.14E-06	1.14E-06								3.00E-05	3.00E-05		6	3
PCBs										1.14E-06	1.14E-06		8	5

AR301166

WORKSHEET 4.

SCORING FOR INDICATOR CHEMICAL SELECTION:
CALCULATION OF CT AND IS VALUES FOR NONCARCINOGENIC EFFECTS
FOR AQUATIC MEDIA.

NAME OF SITE: Bendix - South Montrose
DATE PREPARED: 11 February 1988
ANALYST: LB
VERIFIED BY: SCL
DATE: 16 June 1988

Chemical	Ground Water CT			Residential Wells CT			Surface Water CT			IS Value			Tentative Rank	
	Max	Ave		Max	Ave		Max	Ave		Max	Ave		Max	Ave
Benzene				1.05E-03	4.68E-06		2.34E-04	6.51E-06		1.29E-03	1.12E-05		4	5
Toluene	5.20E-06	5.41E-08		2.60E-05	1.51E-07		3.64E-05	2.17E-06		6.76E-05	2.37E-06		9	7
Ethylbenzene				2.20E-05	2.00E-07		1.10E-05	3.06E-07		3.30E-05	5.06E-07		11	9
Methylene Chloride	5.52E-06	8.63E-08		9.20E-04	1.33E-08					9.26E-04	9.96E-08		5	13
Carbon Tetrachloride	7.93E-03	1.42E-04					3.17E-04	8.81E-06		8.24E-03	1.51E-04		2	4
1,1-Dichloroethane	5.16E-05	1.08E-06					2.58E-05	1.43E-06		7.74E-05	2.51E-06		8	6
1,1,1-Trichloroethane							1.47E-06	1.02E-07		1.47E-06	1.02E-07		13	12
Trans-1,2-Dichloroethene	1.59E-04	6.08E-06					2.65E-03	3.31E-04		2.80E-03	3.37E-04		3	3
Trichloroethene	2.94E-01	1.90E-02		3.05E-02	2.10E-03		4.20E-01	6.31E-02		7.44E-01	8.42E-02		1	1
Tetrachloroethene				2.89E-05	2.80E-07					2.89E-05	2.80E-07		12	10
1,2-Dichloroethane				3.52E-05	1.28E-07					3.52E-05	1.28E-07		10	11
Chlorobenzene				2.86E-04	1.04E-06					2.86E-04	1.04E-06		7	8
Vinyl Chloride	6.14E-04	6.14E-04								6.14E-04	6.14E-04		6	2

AR301167



WORKSHEET 5.
SCORING FOR INDICATOR CHEMICAL SELECTION:
EVALUATION OF EXPOSURE FACTORS AND FINAL CHEMICAL SELECTION
FOR AQUATIC MEDIA.

NAME OF SITE: Bendix - South Montrose
 DATE PREPARED: 11 February 1988
 ANALYST: LB
 VERIFIED BY:
 DATE:

Chemical	IS Value		PC	NC	PC	NC	Parting	Water		Vapor Pressure (mm HG)	Henry's Law Constant (atm-m ³ /mole)	Koc	Half-Life (Days)		IC
	PC	NC						Solubility (mg/L)	Pressure				SW	SOIL	
Benzene	7.37E-07	1.12E-05	6	5	6	5	5	1.75E+03	9.52E+01	5.59E-03	83		0.17		
Toluene	2.37E-06	2.37E-06		7		7	7	5.35E+02	2.81E+01	6.37E-03	300		1.50-7.50		1.30
Ethylbenzene	5.06E-07	5.06E-07		9		9	9	1.52E+02	7.00E+00	6.43E-03	1100		1.20-5.80		1.46
Methylene Chloride	9.96E-08	9.96E-08		13		13	13	2.00E+04	3.62E+02	2.03E-03	8.8				53.20
Carbon Tetrachloride	8.95E-04	1.51E-04	1	4		4	4	7.57E+02	9.00E+01	2.41E-02	110		1.00-5.00		45.00
1,1-Dichloroethane	2.51E-06	2.51E-06		6		6	6	5.50E+03	1.82E+02	4.31E-03	30		0.14-7.00		803.00-1752.00
1,1,1-Trichloroethane	1.02E-07	1.02E-07		12		12	12	1.50E+03	1.23E+02	1.44E-02	152		1.00-6.00		2.10
Trans-1,2-Dichloroethene	3.37E-04	3.37E-04		3		3	3	6.30E+03	3.24E+02	6.56E-03	59		0.30-30.00		80.00
Chloroform	1.98E-05	1.98E-05	4		4			8.20E+03	1.51E+02	2.87E-03	31		1.00-90.00		3.70
Trichloroethene	3.44E-04	8.42E-02	2	1		1	1	1.10E+03	5.79E+01	9.10E-03	126		1.00-30.00		47.00
Tetrachloroethene	2.58E-07	2.80E-07	8	10		10	10	1.50E+02	1.78E+01	2.59E-02	364		0.17		36.00-127.00
1,2-Dichloroethane	4.26E-07	1.28E-07	7	11		11	11	8.52E+03	6.40E+01	9.78E-04	14				
Chlorobenzene	1.04E-06	1.04E-06		8		8	8	4.66E+02	1.17E+01	3.72E-03	330				
Vinyl Chloride	3.00E-05	6.14E-04	3	2		2	2	2.67E+03	2.66E+03	8.19E-02	57		1.00-5.00		1.20
PCBs	1.14E-06		5					3.10E-02	7.70E-05	1.07E-03	530000		2.00-12.9		58.00

AR301168

WORKSHEET 6.
 SCORING FOR INDICATOR CHEMICAL SELECTION:
 CONCENTRATIONS AND Koc VALUES
 IN VARIOUS TERRESTRIAL ENVIRONMENTAL MEDIA.

NAME OF SITE: Bendix - South Montrose
 DATE PREPARED: 11 February 1988
 ANALYST: LB
 VERIFIED BY: SCL
 DATE: 17 June 1988

Chemical	CAS. No.	Koc Value	Subsurface Soil (mg/L)			Sediments (mg/L)		
			Minimum	Maximum	Average	Minimum	Maximum	Average
Benzene	71-43-2	83	ND	5.70E+01	9.90E-01			
Toluene	108-88-3	300	ND	3.60E+01	6.70E-01	ND	1.90E-01	1.07E-01
Ethylbenzene	100-41-4	1100				ND	7.00E-02	2.30E-02
Trans-1,2-Dichloroethene	540-59-0	59	ND	3.80E+01	6.30E-01			
Trichloroethene	79-01-6	126	ND	9.80E+01	2.06E+00			
Tetrachloroethene	127-18-4	364	ND	8.30E+01	1.43E+00			
Benzo(a)anthracene	56-55-3	1380000	ND	7.80E-02	1.53E-02			
Benzo(a)pyrene	50-32-8	5500000	ND	7.30E-02	1.38E-02			

ND - Not detected

AR301169

WORKSHEET 7.
SCORING FOR INDICATOR CHEMICAL SELECTION:
TOXICITY INFORMATION
FOR TERRESTRIAL MEDIA.

NAME OF SITE: Bendix - South Montrose
DATE PREPARED: 10 February 1988
ANALYST: SCL
VERIFIED BY: LB
Date: 17 June 1988

CHEMICAL	TOXICOLOGIC CLASS	EPA RATING VALUE		WATER	SOIL	AIR
		ORAL	INHALATION	T.C.	T.C.	T.C.
Benzene	PC	A	A	7.71E-03	3.86E-07	7.71E-02
	NC	5	10	1.17E-01	5.85E-06	1.18E+02
Benzo(a)anthracene	PC	B2	B2	5.81E-01	2.91E-05	5.81E+00
Benzo(a)pyrene	PC	B2	B2	4.55E+00	2.28E-04	4.55E+01
	NC	8	6	2.67E+01	1.33E-03	1.91E+01
1,2-Dichloroethene (trans)	NC	5	5	5.29E-02	2.65E-06	5.29E-01
Ethylbenzene	NC	4	4	1.10E-02	5.52E-07	1.10E-01
Toluene	NC	7	7	5.20E-03	2.60E-07	5.20E-02
Trichloroethylene	PC	B2	B2	4.29E-03	2.14E-07	4.29E-02
	NC	5	4	1.05E+00	5.26E-05	2.96E+01
Tetrachloroethene	PC	B2	B2	8.86E-03	4.43E-07	8.86E-02
	NC	7	10	9.62E-03	4.18E-07	2.75E-02
1,1,2-Trichloroethane	PC	C	C	1.03E-02	5.14E-07	1.03E-01

PC - Potential carcinogen
NC - Noncarcinogen
T.C. - Toxicity constant

AR301170



WORKSHEET 8.
SCORING FOR INDICATOR CHEMICAL SELECTION:
CALCULATION OF CT AND IS VALUES FOR CARCINOGENIC EFFECTS
IN TERRESTRIAL MEDIA.

NAME OF SITE: Bendix - South Montrose
 DATE PREPARED: 11 February 1988
 ANALYST: LB
 VERIFIED BY: SCL
 DATE: 17 June 1988

Chemical	Subsurface Soil			Sediments			Tentative		
	CT			CT			Rank		
	MAX	AVE		MAX	AVE		MAX	AVE	
Benzene	2.20E-05	3.82E-07		2.20E-05	3.82E-07		2		5
Trichloroethene	2.10E-05	4.41E-07		2.10E-05	4.41E-07		3		4
Tetrachloroethene	3.68E-05	6.33E-07		3.68E-05	6.33E-07		1		2
Benzo(a)anthracene	2.27E-06	4.45E-07		2.27E-06	4.45E-07		5		3
Benzo(a)pyrene	1.66E-05	3.15E-06		1.66E-05	3.15E-06		4		1

AR301171

NAME OF SITE: Bendix - South Montrose
 DATE PREPARED: 11 February 1988
 ANALYST: LB
 VERIFIED BY: SCL
 DATE: 17 June 1988

WORKSHEET 9.
 SCORING FOR INDICATOR CHEMICAL SELECTION:
 CALCULATION OF CT AND IS VALUES FOR NONCARCINOGENIC EFFECTS
 FOR TERRESTRIAL MEDIA.

Chemical	Subsurface Soil			Sediments			Tentative		
	CT			CT			Rank		
	Max	Ave		Max	Ave		Max	Ave	
Benzene	3.33E-04	5.79E-06		3.33E-04	5.79E-06		2	3	
Trans-1,2-Dichloroethene	1.01E-04	1.67E-06		1.01E-04	1.67E-06		3	4	
Ethylbenzene			3.86E-08	3.86E-08	1.27E-08		7	7	
Toluene	9.36E-06	1.74E-07	4.94E-08	9.41E-06	2.02E-07		6	6	
Trichloroethylene	5.15E-03	1.08E-04		5.15E-03	1.08E-04		1	1	
Tetrachloroethene	3.47E-05	5.98E-07		3.47E-05	5.98E-07		5	5	
Benzo(a)pyrene	9.71E-05	1.84E-05		9.71E-05	1.84E-05		4	2	

AR301172

WORKSHEET 10.

SCORING FOR INDICATOR CHEMICAL SELECTION:
EVALUATION OF EXPOSURE FACTORS AND FINAL CHEMICAL SELECTION
FOR TERRESTRIAL MEDIA

NAME OF SITE: Bendix - South Montrose
DATE PREPARED: 12 February 1988
ANALYST: LB
VERIFIED BY: SCL
DATE: 17 June 1988

Chemical	IS Value		PC	NC	Ranking	Water		Vapor Pressure (mm HG)	Henry's Law Constant (atm-m ³ /mole)	Koc	HALF-LIFE (DAYS)			IC
	PC	NC				Solubility (mg/L)	Ranking				SW	SOIL	AIR	
Benzene	3.82E-07	5.79E-06	5	3	3	1.75E+03	9.52E+01	5.59E-03	83		0.17		1.30	+
Toluene		2.02E-07		6	6	6.35E+02	2.81E+01	6.37E-03	300		1.50-7.50		1.46	
Ethylbenzene		1.27E-08		7	7	1.52E+02	7.00E+00	6.43E-03	1100		1.00-6.00		2.10	
Trans-1,2-Dichloroethene		1.67E-06		4	4	6.30E+03	3.24E+02	6.56E-03	59		1.00-90.00		3.70	
Trichloroethene	4.41E-07	1.09E-04	4	1	1	1.10E+03	5.79E+01	9.10E-03	126		1.00-30.00		47.00	+
Tetrachloroethene	6.33E-07	5.98E-07	2	5	5	1.50E+02	1.78E+01	2.59E-02	364					
Benzo(a)anthracene	4.45E-07		3			5.70E+03	2.20E-08	1.16E-06	1380000					
Benzo(a)pyrene	3.15E-06	1.84E-05	1	2	2	1.20E+03	5.60E-09	1.55E-06	5500000					

AR301173

APPENDIX C

EPA MODIFICATION TO THE IARC APPROACH

AR301174



APPENDIX C

The EPA has made the following modifications of the IARC approach to classifying human and animal studies. For human studies:

1. The observation of a statistically significant association between an agent and life threatening benign tumors in humans is included in the evaluations of risk to humans.
2. A "no evidence" category is added. This category indicates that no association was found between exposure and increased risk of cancer in well-conducted, well-designed, independent analytical epidemiologic studies.

For animal studies:

1. An increased incident of combined benign and malignant tumors will be considered to provide sufficient evidence of carcinogenicity if the other criteria defining the "sufficient" category of evidence are met.
2. An increased incident of benign tumors alone as "limited" evidence of carcinogenicity is added.
3. Under specific circumstances, such as the production of neoplasms that occur with high spontaneous background incident, the evidence may be decreased to "limited" if warranted.
4. A "no evidence" category is also added.

Agents that are judged to be in the EPA Weight-of-Evidence stratification Groups A and B are to be regarded as suitable for quantitative risk assessments. The appropriateness of quantifying the risks from agents in Group C, specifically agents that are at the boundary of Group C and D, would be judged on a case-by-case basis. Agents that are judged to be in Groups D and E should generally not be evaluated using quantitative risk assessments.

Evidence of carcinogenicity from human studies comes from three main sources:

1. Case reports of individual cancer patients who were exposed to the agent(s).
2. Descriptive epidemiological studies.
3. Analytical epidemiologic (case control and cohort studies).

Three criteria must be met before a causal association can be inferred between exposure and cancer in humans:

1. There is no identified bias which can explain the association.
2. The possibility of confounding has been considered and ruled out as explaining the association.
3. The association is unlikely to be due to chance. The degrees of evidence for carcinogenicity from studies in humans can be categorized by:
 - a. Sufficient evidence of carcinogenicity, which indicates that there is a causal relationship between the agent and human cancer.

b. Limited evidence of carcinogenicity, which indicates that a causal interpretation is credible.

c. Inadequate evidence.

i. There were few pertinent data, or

ii. The available studies, while showing evidence of association, did not exclude association, did not exclude chance, bias or confounding.

4. No evidence.

5. No data.

Assessment of evidence for carcinogenicity from studies in experimental animals are classified into five groups:

1. Sufficient evidence of carcinogenicity, which indicates an incident of malignant tumors or combined malignant and benign tumors:

a. In multiple species or strains; or

b. In multiple experiments (preferably with different routes of administration or using different dose levels); or

c. To an unusual degree with regard to incidence, site or type of tumor, or age at onset.

2. Limited evidence of carcinogenicity.

AR301177



- a. Studies involve a single species, strain, or experiment; or
 - b. The experiments are restricted by inadequate dose levels, inadequate duration of exposure to the agent, inadequate period of follow-up, poor survival, too few animals, or inadequate reporting; or
 - c. An increase in the incident of benign tumors only.
- 3. Inadequate evidence.
 - 4. No evidence.
 - 5. No data.

The categorization of overall evidence of carcinogenicity is subdivided into five groups.

Group A: Human carcinogens are used only when there is sufficient evidence from epidemiologic studies to support the causal association between exposure to agent(s) and cancer.

Group B: Probable human carcinogens include agents for which the evidence of human carcinogenicity from epidemiologic studies ranges from almost "sufficient" to "inadequate". B1 is reserved for agents for which there is at least limited evidence of carcinogenicity to humans from epidemiologic studies. The agents for which there is inadequate evidence from human

AR301178



studies but sufficient evidence from animal studies would usually result in a classification of B2.

Group C: Possible human carcinogens are used for agents with limited evidence of carcinogenicity in animals in the absence of human data. It includes a wide variety of evidence:

- a. Definitive malignant tumor response in a single well-conducted study,
- b. Marginal tumor responses in studies having inadequate design for reporting,
- c. Benign but not malignant tumors with an agent showing no response in a variety of short-term tests for mutagenicity, and
- d. Marginal responses in a tissue known to have a high and variable background rate.

Group D: Not classified is used for agent(s) with inadequate animal evidence of carcinogenicity.

Group E: No evidence of carcinogenicity for humans is used for agent(s) that shows no evidence for carcinogenicity in at least two adequate animal studies in different species or in both epidemiologic and animal studies.

The text for the general weight-of-evidence discussion is taken from proposed guidelines for carcinogen risk assessment (1).

The Carcinogen Assessment Group (CAG) has evaluated fifty-four chemicals as suspect human carcinogens and developed relative carcinogenic potency factors for each chemical. The ranking of potency indices is subjected to the uncertainty of comparing different routes of exposure and a number of different species. These indices are based on estimates of low dose risk using linear multistage extrapolation from the observed range. Thus, these indices are not valid when compared to potencies in the experimental or observational range, especially, if linearity does not exist in this range.

APPENDIX D

**TOXICOLOGY PROFILES OF THE
INDICATOR COMPOUNDS FOR THE
BENDIX AEROSPACE
ENDANGERMENT ASSESSMENT**

Trichloroethylene
trans-1,2-Dichloroethylene
Vinyl chloride
Benzene

AR301181



APPENDIX D

Trichloroethene

References: (16,23,24)

Summary of Health Effects Data

Trichloroethene (TCE) has a low acute toxicity. In single species tests the acute oral LD₅₀ value ranges from 6000 to 7000 mg/kg. Chronic exposure of rodents to high doses has been found to cause adverse effects on the liver and kidneys. In long-term studies TCE has induced hepatocellular carcinomas in mice. Due to the presence of carcinogenic impurities in the test compounds and other factors, the significance of these findings is not clear. Extensive epidemiological investigations have failed to substantiate an increased carcinogenic risk in man. Also, results from short-term testing have been ambiguous.

Pharmacokinetics and Metabolism

Trichloroethene can be absorbed through dermal or oral contact or by inhalation. Direct contact with the pure liquid will permit some absorption, which normally is not high enough to elicit toxic effects. Upon ingestion, trichloroethene is readily absorbed, but inhalation usually represents the major route of absorption. Pulmonary uptake of TCE is rapid, and distribution occurs to all body tissue. An appreciable amount of the TCE inhaled is rapidly excreted unmetabolized in exhaled air. However, the substance is also extensively metabolized, by the liver (i.e., in man 40-70% of the retained dose). In the liver, TCE is converted to trichloroethanol, trichloroethylene-glucoronide, and trichloroacetic acid; which are eliminated as urinary metabolites. Although elimination from

fatty tissues occurs at a slow rate, virtually all TCE is excreted within 48 hours after administration of a single high dose.

Toxic and Carcinogenic Studies

TCE has a low acute toxicity in mammals. In man, high concentrations produce anesthetic and analgesic responses and are known to occasionally elicit cardiac arrhythmias. Chronic exposure has been reported to induce neurotoxic symptoms like ataxia, sleep disturbances, and psychotic episodes as well as trigeminal neuropathy.

In rodents TCE causes kidney and liver damage. However, no significant signs of developmental toxicity have been found through inhalation experiments.

Applicable and Relevant Standards

The applicable and relevant standards for TCE are summarized in Table D-1. The ambient water quality criterion for the protection of Aquatic biota is 45.0 mg/l. A Maximum Contaminant Level in drinking water has been established at 0.005 mg/l for TCE. Regulations for workplace exposures have been developed by OSHA (100 ppm TWA or 540 mg/m³) and ACGIH (50 ppm or 270 mg/m³). Trichloroethene is considered a probable human carcinogen, and the CAG has calculated lifetime risks at 28, 2.8, and 0.28 ug/l (drinking water), for 10⁻⁵, 10⁻⁶, 10⁻⁷ cancer risk, respectively.

**TABLE D-1
SUMMARY OF TOXICOLOGICAL INFORMATION FOR
TRICHLOROETHYLENE**

<u>Relevant Requirements, Criteria, Advisories or Guidance</u>	<u>Value</u>
EPA MCL (mg/L)	0.005
EPA MCLG (proposed)	0
EPA Water Quality Criteria (mg/L)	
fish and drinking water	2.70E-03
fish only	8.07E-02
lowest reported toxic concentration	45.0
EPA Drinking Water Health Advisories (mg/L)	
1 day	none
10 days	none
chronic	none
OSHA 8 hr TWA ppm(mg/m3)	100 (540)
ACGIH 8 hr TWA ppm(mg/m3)	50 (270)
<u>Noncarcinogenic effects</u>	
risk characterization	
oral (mg/kg/day)	
AIC	none
AIS	none
ADI	0.54
inhalation (mg/kg/day)	
AIC	none
AIS	none
ADI	none
median effective dose (mg/day)	
oral	9.50
inhalation	2.70
<u>Carcinogenic effects</u>	
Carcinogenic Potency Factor (1.0E-06 cancer risk)	
oral 1/(mg/kg/day)	1.10E-02
inhalation	4.60E-03
10% effective dose(mg/kg/day)	
oral	6.67E+00
inhalation	6.67E+00
Cancer Risk	
Inhalation at 1 ug/m3 (risk)	4.10E-06
water (ug/L, 1.0E-06 risk)	2.80E+00
Classification, EPA	B2
Classification, IARC	insufficient evidence

trans-1,2-Dichloroethene

References: (22,23,24)

Summary of Health Effects Data

This is a lack of information concerning exposure to trans-1,2-dichloroethene. There are no reports of carcinogenic or teratogenic activity by trans-1,2-dichloroethene in animals or humans. Test results from a Variety of in vitro exposure systems did not indicate any mutagenic activity. Like other members of the chlorinated ethene series, trans-1,2-dichloroethene has anesthetic properties. In human studies, exposure to high vapor concentrations has been found to cause nausea, vomiting, weakness, tremor, and cramps. Rats repeatedly exposed via inhalation to 800 mg/m³ of trans-1,2-dichloroethene (8 hours/day, 5/days/week, for 16 weeks) exhibited liver damage. The oral LD₅₀ value for the rat is 1,300 mg/kg.

Pharmacokinetics and Metabolism

Upon exposure, trans-1,2-dichloroethene may elicit toxic responses via ingestion, inhalation, or contact with the skin or eyes. At this time there is no data available regarding the compartmental distribution of trans-1,2-dichloroethene in the body. However, if this isomer acts similarly to 1,1-dichloroethene, the highest concentrations will be found in the liver and kidney. In Vitro studies have shown that mammalian live microsomes can metabolize trans-1,2-dichloroethene to dichloroacetic acid and dichloroethanol. Elimination of trans-1,2-dichloroethene from the body occurs primarily through expired air, but the metabolite is eliminated through the urine.

Toxic and/or Carcinogenic Studies

trans-1,2-Dichloroethene vapor is a narcotic and a mucous-membrane irritant. The trans-isomer is about twice as potent as the cis-isomer in depressing the central nervous system. Short-term exposure in animals at high levels resulted in general anesthetic and narcotic effects. The oral LD₅₀ value for the rat is 1300 mg/kg. Rats, rabbits, guinea pigs and dogs exposed (7 hours/day, 5 days/week, 6 months) to either 500 or 1000 ppm of 1,2-dichloroethene showed no changes in growth, mortality, body and/or organ weight, hematology, clinical chemistry, or gross and microscopic pathology. Rats exposed via inhalation to 1000 ppm of 1-2-dichloroethene for 8 hours had reduced serum albumin, urea nitrogen, and alkaline phosphatase levels. Test results from a variety of in vitro exposure systems did not indicate any mutagenicity. No data are available on the teratogenic effects of trans-1,2-dichloroethene.

Applicable and Relevant Standards

The applicable and relevant standards for trans-1,2-dichloroethene are summarized in Table D-2. The ambient water quality criterion for the protection of fresh water life is 135 mg/l. A Maximum Contaminant Level Goal (MCLG) in drinking water has been proposed at 0.07 mg/l. An acceptable intake for chronic exposures (AIC) of 0.01 mg/kg/day has been established based upon the EPA's Health Advisory or Reference dose for lifetime exposure. A tentative acceptable intake for subchronic exposures (AIS) has been calculated by ERM at 0.272 mg/kg/day. This calculation is based on a one-day EPA Health Advisory of 2.72 mg/l for a 10 kg child. Regulations for workplace exposures have been developed by OSHA and ACGIH at 200 ppm or 790 mg/m³. trans-1,2-Dichloroethene is considered to be a noncarcinogen by EPA.

TABLE D-2
SUMMARY OF TOXICOLOGICAL INFORMATION FOR
trans-1,2-DICHLOROETHYLENE

<u>Relevant Requirements, Criteria, Advisories or Guidance</u>	<u>Value</u>
EPA MCL (mg/L)	none
EPA MCLG (mg/L) (Proposed)	0.07
EPA Water Quality Criteria (mg/L)	
Clean Water Act Water Quality Regulation (mg/L)	
fish and drinking water	none
fish only	none
protection of aquatic life	<135
EPA Drinking Water Health Advisories (mg/L) 10kg(70kg)	
1 day	2.72
10 days	1.00
chronic	1.00(3.50)
OSHA 8 hr TWA ppm(mg/m3)	200(790)
ACGIH 8 hr TWA ppm(mg/m3)	200(790)
<u>Noncarcinogenic effects</u>	
risk characterization	
oral (mg/kg/day)	
AIS (from health advisories)	0.272
AIC (from health advisories)	0.01
ADI	none
inhalation (mg/kg/day)	
AIS	none
AIC	none
ADI	none
median effective dose(mg/day)	
oral	1.89E+02
inhalation	1.89E+02
<u>Carcinogenic effects</u>	
Carcinogenic Potency Factor (1.0E-06 risk)	none
oral 1/(mg/kg/day)	none
inhalation	none
10% effective dose(mg/kg/day)	
oral	none
inhalation	none
Cancer Risk	
Inhalation at 1 ug/m3 (risk)	none
water (ug/L,1.0E-06 risk)	none
Classification, EPA	Noncarcinogen
Classification, IARC	Not ranked

AR301187.



VINYL CHLORIDE

References: (21,23,24)

Summary of Health Effects Data

Vinyl chloride is a human carcinogen that causes angiosarcomas of the liver, tumors of the brain, lung, and hematolymphopoietic system. There is suggested evidence that vinyl chloride has teratogenic and reproductive effects in both humans and animals. Chronic human exposure to vinyl chloride is associated with multiple systemic disorders, including a sclerotic syndrome, acro-osteolysis, and liver damage. Acute human exposure to high concentrations can cause narcosis, respiratory tract irritation, bronchitis, and memory disturbances. Animals chronically exposed to vinyl chloride exhibited lesions of the liver, kidney, spleen, and lungs. Concentrations encountered by workers using or producing vinyl chloride are reportedly quite variable and may range from less than the limit of detection to several grams per cubic meter. In laboratory animals, acute inhalation exposure to high levels of vinyl chloride can result in narcosis or death. The 2-hour LC₅₀ value for rats is 390 g/m³. Chronic exposure of laboratory animals to vinyl chloride can result in growth disturbances, and cause histopathological and histochemical lesions in the liver, kidney, spleen, and lungs.

Pharmacokinetics and Metabolism

Vinyl chloride is readily absorbed upon inhalation or in the gastrointestinal tract when dissolved in a suitable carrier. The substance is rapidly distributed throughout the body. Part of the absorbed dose is excreted unchanged via expired air, the remainder is metabolized via epoxidation to various polar endproducts which are excreted in the urine.

Toxic and Carcinogenic Effects

The acute toxicity of vinyl chloride is low. Short-term human exposure to high concentrations primarily causes depression of the central nervous system. Chronic exposure to vinyl chloride has been associated with multiple systemic disorders involving sclerodermatous skin damage, acro-osteolysis, Raynaud's phenomenon, and hepatic and renal damage. There is also evidence from experimental studies utilizing laboratory animals, as well human exposures suggesting that vinyl chloride is teratogenic and causes toxic effects on reproduction.

Vinyl chloride causes tumors at multiple sites (liver, lung, brain, kidney) in experimental animals (mice, rats, and hamsters) after oral administration or upon inhalation. In man, exposure has been associated with angiosarcomas of the liver and tumors of brain, lung, and the hematolymphopoietic system.

Reports of increased incidences of tumors of the digestive system, urinary tract, and breast have been judged inadequate by IARC to evaluate the carcinogenicity of vinyl chloride for these sites. The substance has been found to be genotoxic in several short-term tests.

EPA and IARC have classified vinyl chloride as a human carcinogen. The Carcinogen Assessment Group of EPA has determined a carcinogenicity potency factor of about 2×10^{-2} (mg/kg/day)⁻¹ for this carcinogen.

Applicable and Relevant Standards

The applicable and relevant standards for vinyl chloride are summarized in Table D-3. Insufficient data exist to determine the ambient water quality criterion for the protection of fresh water life. An established MCL (Maximum Contaminant Level) in drinking water has been established at 0.002 mg/l for vinyl

TABLE D-3
SUMMARY OF TOXICOLOGICAL INFORMATION FOR
VINYL CHLORIDE

Relevant Requirements, Criteria, Advisories or Guidance	Value	
EPA MCL (mg/L)	2.00E-03	
EPA MCLG (proposed, mg/L)	0	
EPA Water Quality Criteria (mg/L)		
fish and drinking water	2.00E-03	
fish only	5.25E-01	
protection of aquatic life	insufficient data	
EPA Drinking Water Health Advisories (mg/L)	10 kg	70 kg
1 day	2.60	- - -
10 days	2.60	- - -
chronic	0.013	0.046
OSHA 8 hr TWA(mg/m3)	1 (2)	
ACGIH 8 hr TWA(mg/m3)	5 (10)	
<u>Noncarcinogenic effects</u>		
risk characterization		
oral (mg/kg/day)	none	
AIC	none	
ADI (adjusted for drinking water exposure)	2.00E-03	
median effective dose (mg/day)		
oral	2.28E+02	
inhalation	2.28E+02	
<u>Carcinogenic effects</u>		
Potency Factor 1/(mg/kg/day) (1.0E-06 cancer risk)		
oral 1/(mg/kg/day)	2.30E+00	
inhalation 1/(mg/kg/day)	2.50E-02	
10% effective dose mg/kg/day		
oral	6.67E+00	
inhalation	6.67E+00	
Cancer Risk		
Inhalation at 1 ug/m3 (risk)	3.00E-06	
water (ug/L,1.0E-06 risk)	1.50E-02	
Classification, EPA	Group A	
Classification, IARC	Group 1	

chloride. Regulations for work place exposure are 65 ppm (130 mg/m³) for OSHA and 5 ppm (10 mg/m³) for ACGIH. Vinyl chloride is a known human carcinogen and the CAG has calculated lifetime risks at 0.15, 0.015, and 0.0015 ug/l (drinking water), for 10⁻⁵, 10⁻⁶, 10⁻⁷, respectively. Vinyl chloride has been classified as a Class A Carcinogen by EPA.

BENZENE

References: (17,23,24)

Summary of Health Effects Data

Benzene is a recognized human carcinogen. Several human epidemiological studies provide sufficient evidence of a causal relationship between benzene exposure and leukemia. Benzene is a known inducer of aplastic anemia in humans, with a latent period of up to 10 years. It produces leukopenia and thrombocytopenia, which may progress to pancytopenia. Similar adverse effects on the blood cell-producing system occur in animals exposed to benzene. In both humans and animals, benzene exposure is associated with chromosomal damage, although it is not mutagenic in microorganisms. Benzene is fetotoxic and causes exmbryo lethality in laboratory animals.

Pharmacokinetics and Metabolism

The absorption routes of benzene into the body are dermal, inhalation, and oral. Dermal and oral absorptions are presumed minor compared to inhalation. Inhalation is the most important absorption route of workers because of the high volatility of benzene. An estimated 12-50% of benzene-contaminated inspired air is expired unchanged by humans. In the body, benzene is metabolized by the mixed function oxidase system, to an intermediate which interacts with cellular constituents to form phenol (major metabolite), hydroquinol and catechol (minor metabolites). Further metabolism occurs to alkaline salts and glucuronide conjugates. All of the metabolites are excreted in the urine.

Toxic and/or Carcinogenic Studies

Exposure to very high concentrations of benzene [about 20,000 ppm (66,000 mg/m³) in air] can be fatal within minutes. The prominent signs are central nervous system depression and convulsions, with death usually following as a consequence of cardiovascular collapse. Milder exposures can produce vertigo, drowsiness, headache, nausea, and eventually unconsciousness if exposure continues. Deaths from cardiac sensitization and cardiac arrhythmias have also been reported after exposure to unknown concentrations. Although most benzene hazards are associated with inhalation exposure, dermal absorption of liquid benzene may occur, and prolonged or repeated skin contact may produce blistering, erythema, and a dry, scaly dermatitis. Depression and increased susceptibility to tuberculosis and pneumonia have been attributed to benzene exposures.

No supporting evidence suggests that benzene is teratogenic; however, in utero benzene is a potent inhibitor of growth. Benzene was found non mutagenic in several assays, but some positive results were found in sister chromatid exchange experiments in mice.

The Carcinogen Assessment Group (CAG) has evaluated more than 50 chemicals for relative human carcinogenic potency. Based on this evaluation, the level of evidence for benzene from both animal and human studies is sufficient to classify it as a human carcinogen. Based on IARC criteria, benzene is classified as a Class 1 ("known" human) carcinogen.

Applicable and Relevant Standards

The applicable and relevant standards for benzene are summarized in Table D-4. The ambient water quality criterion for the protection of fresh water life is 5.3 mg/l. A Maximum Contaminant Level (MCL) has been established at 0.005 mg/l in

**TABLE D-4
SUMMARY OF TOXICOLOGICAL INFORMATION FOR
BENZENE**

<u>Relevant Requirements, Criteria, Advisories or Guidance</u>	<u>Value</u>
EPA MCL (mg/L)	0.005
EPA MCLG (proposed, mg/L)	0
EPA Water Quality Criteria (mg/L)	
fish and drinking water	6.60E-04
fish only	4.00E-02
protection of aquatic life	none
lowest reported toxic concentration	5.3
EPA Drinking Water Health Advisories (mg/L)	
1 day	0.235
10 days	0.235
chronic	none
OSHA 8 hr TWA ppm(mg/m3)	1 (3)
ACGIH 8 hr TWA ppm(mg/m3)	10 (30)
<u>Noncarcinogenic effects</u>	
risk characterization	
oral (mg/kg/day)	
AIC	none
AIS	none
ADI	none
inhalation (mg/kg/day)	
AIC	none
AIS	none
ADI	none
median effective dose (mg/day)	
oral	8.55E+01
inhalation	1.70E+00
<u>Carcinogenic effects</u>	
Carcinogenic Potency Factor (1.0E-06 cancer risk)	
oral 1/(mg/kg/day)	5.20E-02
inhalation	2.60E-02
10% effective dose(mg/kg/day)	
oral	3.70E+00
inhalation	3.70E+00
Cancer Risk	
Inhalation at 1 ug/m3 (risk)	4.10E-06
water (ug/L, 1.0E-06 risk)	7.00E-01
Classification, EPA	A
Classification, IARC	1

AR301194

drinking water for benzene. Regulations for workplace exposure to benzene have been established by both OSHA and ACGIH at 10 ppm (30 mg/m³). Benzene is a known human carcinogen, and the CAG has calculated lifetime risks at 7, 0.7, and 0.007 ug/l (drinking water), for 10⁻⁵, 10⁻⁶, 10⁻⁷, respectively. Benzene has been classified as a Class A carcinogen by EPA.

APPENDIX E

**ENVIRONMENTAL FATE AND TRANSPORT
OF THE INDICATOR COMPOUNDS
FOR THE BENDIX AEROSPACE
SOUTH MONTROSE, PENNSYLVANIA
ENDANGERMENT ASSESSMENT**

Trichloroethylene
trans-1,2-Dichloroethylene
Vinyl chloride
Benzene

AR301196



APPENDIX E

TRICHLOROETHENE

General:

Trichloroethene (TCE) is ubiquitous in the environment, although it is not naturally occurring. Widely used as a solvent in industrial degreasing of metals, TCE has minor uses in fumigant mixtures, inhalation anesthesia, and decaffeination of coffee. TCE is a highly volatile unsaturated aliphatic hydrocarbon with a relatively high water solubility. From its density, any TCE in excess of its water solubility would sink to the bottom of the water.

Fate and Transport:

Volatilization of TCE in the environment is its most important fate process. Its laboratory half-life is reported to be 21 minutes. Once the compound enters the troposphere, high temperatures and UV radiation promote rapid degradation ($t_{1/2} = 4$ days) to hydrochloric acid (HCl), dichloroacetyl chloride, phosgene, carbon monoxide, and hexachlorobutadiene. The overall half-life of TCE in surface water and air is 1-90 days and 4 days, respectively. Limited laboratory studies on the sorption of TCE onto soils and sediments indicate that TCE does not sorb to a great extent to pure clays (<5 percent sorption). Thus, sorption will not be considered as a major fate process. TCE does not significantly bioaccumulate in the environment as seen by bioconcentration factors of 10^{-17} for bluegills, with a half-life in tissue of less than 1 day. Higher mammals, including man, can degrade TCE to chlorinated acetic acids.

Under anerobic conditions, TCE can degrade to carbon dioxide in subsurface environments. However, biodegradation/biotransformation is considered of minor significance as an environmental fate process.

Summary:

The major environmental transport process for of TCE is volatilization from water and soils to the atmosphere.

References:

Callahan, M.A. et al., 1979; Mills, W.B. et al., 1982, U.S. EPA, 1985f; Schuller, T.A., 1983; Wilson and Wilson, 1985.

TRANS-1,2-DICHLOROETHENE

General:

trans-1,2-Dichloroethene is a colorless liquid with an ether-like odor. It has many uses as a solvent, in rubber manufacturing, as a refrigerant, and as an additive to dye and lacquer solutions. It is also used as a constituent of perfumes and thermoplastics. trans-1,2-Dichloroethene is only slightly soluble in water. When its water solubility is exceeded, this chemical will sink in a column of water.

Fate and Transport:

Volatilization appears to be the major transport process for trans-1,2-dichloroethene in surface water and soils. The volatilization half-life in surface water is reported to be 22 minutes. Once in the troposphere, the chemical is attacked at the double bond by hydroxyl radicals to form formic acid, hydrochloric acid, and carbon monoxide. The tropospheric half-life of trans-1,2-dichloroethene, based on its rate of reaction with hydroxyl radicals, is probably less than one day. Based on its rate of oxidation in the troposphere, little or no trans-1,2-dichloroethene would be expected to migrate into the stratosphere; thus photolysis is probably a minor fate process in the atmosphere. Photolysis does not appear to be an important fate process in the terrestrial or aquatic environments. Oxidation and hydrolysis in the aquatic environment do not appear to be significant. Based on its K_{OC} , trans-1,2-dichloroethene probably does not sorb to soils and sediments to any extent. Based on its octanol/water partition coefficient (K_{OW}), this compound probably does not bioaccumulate. Trans-1,2-Dichloroethene does biodegrade in the environment, especially under anaerobic conditions. However, rates of

degradation are probably slow; therefore, biodegradation is probably not an important fate process.

Summary:

The major environmental fate and transport process for trans-1,2-dichloroethene is volatilization from surface water and soils to the troposphere with subsequent attack by hydroxyl radicals.

References:

Callahan, M.A., et al., 1979; Verschueren, K., 1983; Vogel, T.M., et al., 1987.

VINYL CHLORIDE

General:

Vinyl Chloride (chloroethene) is a starting material in the manufacture of PVC and other copolymers. It is moderately water soluble and is an extremely volatile unsaturated aliphatic hydrocarbon. Based upon its density, vinyl chloride would float if its water solubility were exceeded.

Fate and Transport:

Volatilization is the predominant fate process for vinyl chloride in the environment. The laboratory volatilization half-life of vinyl chloride from water is 26 minutes while the overall half-lives in air and surface water are 1 day and 1-5 days, respectively. Once in the troposphere, vinyl chloride reacts rapidly ($t_{1/2}$ = few hours) to form hydrogen chloride (HCl) and formyl chloride (HCOCl) and, subsequently, carbon monoxide and hydrogen chloride ($t_{1/2}$ = 20 minutes). Studies indicate that volatilization proceeds so rapidly that the slower fate processes (photolysis, hydrolysis, and bioaccumulation) cannot occur. Sorption and biodegradation studies show minimal evidence that these processes occur for vinyl chloride.

Summary:

The predominant transport process for vinyl chloride from soils and water is volatilization to the atmosphere followed by oxidation in the troposphere.

References

AR301201



Verschueren, K., 1983; Weast, R.C., 1974-1975; Mills, W.B., et al., 1982; U.S. EPA, 1985f; Callahan, M.A., et al., 1979; Mabey, W.R., et al., 1982.

BENZENE

General:

Benzene occurs naturally in the environment, but man-made inputs/releases have greatly increased its concentrations in various media. Predominantly used as a starting material in the synthesis of organic chemicals, benzene is also used as a commercial solvent and in pesticides. A moderately volatile organic chemical with a high water solubility, benzene has a low chemical reactivity based upon the stability of the aromatic ring. From its density and water solubility, any benzene in excess of its water solubility would rise to the top of water.

Fate and Transport:

The major environmental fate process is volatilization of benzene from both soil and water to the atmosphere. The volatilization half-life of benzene in water at 25°C has been calculated at 4.8 hours. The overall half-life of benzene in water is estimated at 1-6 days. Once volatilized, benzene is available for oxidation by hydroxyl radicals, yielding phenol and ozone. The atmospheric half-life of benzene in rural and urban settings is calculated to be 458 and 46 hours respectively, with an overall atmospheric half-life greater than 1 day. Sorption onto soils, sediments, and suspended particles occurs on a limited basis, thus, sorption is a less important fate process. Benzene can be considered moderately mobile in soils. Studies show that microorganisms in soil and water are capable of biodegrading benzene. However, this process is slow compared to the rate of volatilization. Benzene is resistant to hydrolysis and photolysis. Little is known about the bioaccumulation of benzene, but based upon its octanol/water partition coefficient, it is anticipated to be very low.

Summary:

The major environmental transport process for benzene is volatilization from soil and water to the atmosphere.

References:

Mabey, W.R., et al., 1982; Mills, W.B., et al. 1982; U.S. EPA, 1985g; Gilbert, D., et al., 1980; Callahan, M.A., et al., 1979; Prasad, S.S., et al., 1985.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION III

841 Chestnut Building
Philadelphia, Pennsylvania 19107

SUBJECT: ALLIED-BENDIX RISK ASSESSMENT

DATE: 29 July 88

FROM: BRUCE MOLHOLT *B*

TO: PATRICIA TAN

I have reviewed ERM's risk assessment for the Allied-Bendix Aerospace site in South Montrose, PA. Overall, I agree with their conclusion that VOCs at the site represent acceptable risk with the exception of vinyl chloride migration from the old landfill area to the regional aquifer. However, the total risk from vinyl chloride was slightly underestimated.

Referring to Table 5-3, the carcinogenic potency of vinyl chloride by inhalation is $2.95E-1$ rather than the $2.5E-2$ stated. Hence "Route/Chemical Specific Risk" for VC inhalation from ambient regional aquifer east should read $1.75E-4$ rather than $1E-5$, and the total risk from this aquifer is then $6.35E-4$ rather than the stated $5E-4$.

I don't feel that this increased risk for vinyl chloride (by 27 percent) is sufficient to change the conclusions of the report.

All-in-all, this was a very sound risk assessment.

If there are any further questions, please do not hesitate to contact me.

cc: Laura Boomazian

AR301205